

FIELD EXPEDIENT ARMOR MODIFICATIONS
TO US ARMORED VEHICLES

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Military History

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ABSTRACT

Field Expedient Armor Modifications to US Armored Vehicles, by MAJ Matthew A. Boal, 103 pages.

This thesis examines field expedient modifications to US armored vehicles by US Army and US Marine Corps armored vehicle crewmen during World War II, the Korean War and the Vietnam War. Two major categories of modifications are examined. They are modifications to improve the primary protection of armored vehicles and modifications to improve the secondary protection of armored vehicles. Some of the specific types of modifications analyzed are hedgerow cutters, sand bagging, addition or modification of ancillary weapons, communications improvements, camouflage, rocket propelled grenade screens, and addition of concrete.

This thesis determines that field expedient modifications to improve the primary protection of armored vehicles against the enemy's primary armor killing weapons were not effective during all three wars under study. Additionally, this thesis shows that field expedient modifications to improve the primary and secondary protection of armored vehicles against lesser threats were successful in some cases. The positive psychological impact on armored vehicle crews or field expedient modifications justified the time and resource allocation required for crews to conduct field expedient modifications during all of the conflicts considered.

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TABLE OF CONTENTS

	Page
MASTER OF MILITARY ART AND SCIENCE THESIS APPROVAL PAGE	ii
ABSTRACT.....	iii
ACKNOWLEDGMENTS	iv
ACRONYMS	vi
CHAPTER 1. INTRODUCTION	1
CHAPTER 2. WORLD WAR II.....	13
US Equipment.....	13
The Axis Threat	18
World War II Improvisations.....	21
The Hedgerow Problem.....	26
Field Telephones	31
Camouflage.....	33
Other Modifications	35
CHAPTER 3. THE KOREAN WAR.....	42
US Equipment.....	43
Communist Equipment	47
Mine Warfare.....	51
Protection Modifications.....	52
Other Modifications	55
CHAPTER 4. THE VIETNAM WAR.....	62
US Equipment.....	62
Communist Equipment	66
Protection Modifications.....	70
Other Modifications	76
CHAPTER 5. CONCLUSION.....	83
BIBLIOGRAPHY	88
INITIAL DISTRIBUTION LIST	95
CERTIFICATION FOR MMAS DISTRIBUTION STATEMENT	96

ACRONYMS

ACAV	Armored Cavalry Assault Vehicle
ACOV	Armored Combat Operations in Vietnam
AFV	Armored Fighting Vehicle
APC	Armored Personnel Carrier
AFF	Army Field Forces
AGF	Army Ground Forces
ARVN	Army of the Republic of Vietnam
BG	Brigadier General
CPL	Corporal
ETO	European Theater of Operations
GEN	General
LTC	Lieutenant Colonel
LTG	Lieutenant General
LVT(A)-4	Landing Vehicle, Tracked, Armored 4
LVT(A)-5	Landing Vehicle, Tracked, Armored 5
LVTP-5	Landing Vehicle, Tracked, Personnel 5
MAJ	Major
MG	Major General
NVA	North Vietnamese Army
OCAFF	Office, Chief of Army Field Forces
PTO	Pacific Theater of Operations
RPG	Rocket Propelled Grenade

SECMA	Study and Evaluation of Countermine Warfare
SGT	Sergeant
TUSK	Tank Urban Survival Kit
VC	Viet Cong

CHAPTER 1

INTRODUCTION

What the American tanker wants is, a high-velocity weapon, as high or higher than the Germans, mounted on a tank of equal maneuverability, and added armor plate.¹

SGT R. M. Robbins and CPL W. McGrail,
“A Report on United States vs. German Armor”

Sergeant Rains M. Robbins and Corporal Walter McGrail from the 2nd Armored Division made the comment above in the spring of 1945 as the war in Europe was drawing to a conclusion. Robbins and McGrail were American tank crewmen who eloquently expressed the problem crewmen faced from the day the first tank entered combat on the Somme battlefield on 15 September 1916.² From that time armies struggled to find the perfect balance of guns, armor and speed for their armored vehicles. Crews and units struggled to improve the armored vehicles they received from their army in any way they could.

There are three terms most commonly used to describe the qualities that developers of armored combat vehicles use to evaluate the basic effectiveness of those systems: mobility, firepower, and protection. “Mobility” refers to how fast a vehicle can move, how well it traverses various types of terrain and how well its mechanical means of propulsion and suspension behave. “Firepower” describes the range, accuracy and destructive power of a vehicle's weapons systems. The term “protection” defines how well the vehicle prevents its operators from being killed or wounded by enemy weapons. The challenge throughout the history of armored vehicle development has been for

designers to balance these three components in relationship to each other to achieve a workable combat system that meets the needs of forces on the battlefield.

This balancing act usually takes place on designers' drafting tables, in research and development facilities and on testing ranges before war occurs. The design and development process is costly, laborious, and time consuming. The development of armored vehicles also suffers from the realities imposed by fiscal constraints that military forces must operate under. The mobility, firepower and protection of a particular armored vehicle are determined long before a crew cranks the engine and crosses the line of departure for combat operations. Major changes to existing vehicles or development of new systems requires long-lead times and significant resources.

Crews facing combat possess little ability to significantly change the mobility and firepower of their mounts immediately before or during combat. For example, an American crew unhappy with the performance of their tank's engine could not go out and find a better engine and replace it in their tank on the eve of Operation Overlord in 1944. Likewise, it is difficult for a crew or unit to change the basic firepower of their combat vehicle during operations. Conceivably, they could modify or add ancillary weapons systems, but it is impractical that the same American crew from the previous example could find a better main gun and upgrade their own tank in a staging area in England in May 1944.

The one element that crews do have some capability to affect is the area of protection. Individual crews, sometimes entire units, can make modifications and additions to their combat vehicles to improve its protection. Usually the changes that crews make fall into the category of adding more material to the armor of the system to

enhance the vehicle's capability to resist enemy weapons effects. To complete the example from above, it is conceivable that a crew could easily add sandbags or spare sections of track to their tank prior to landing in Normandy. Additionally, crews could also attempt to improve their tanks' protection after landing in Normandy.

Field expedient modification of armored vehicle protection is the focus of this thesis. Specifically, this work will attempt to answer the following primary research question: Did the field expedient modifications that crews made to their armored vehicles provide real improvement to the levels of protection their vehicles exhibited? This study seeks to determine how effective, in terms of lives saved, the changes the crews made really were.

The first subordinate research question that must be answered prior to arriving at a logical conclusion is: What was the effectiveness of the protection that armored vehicles provided before crews began making modifications to their vehicles? This question is necessary to establish a baseline of information on the vehicles' protection as they rolled off the production line. Once the baseline is established, it becomes necessary to develop post-modification data to compare with the baseline data.

There is an intermediate question that must be answered prior to comparing pre-modification and post-modification data: What were the specific modifications that crews made to their armored vehicles to improve the level of protection from enemy weapons systems? These are the actual processes and materials that crews used to modify their combat vehicles in the field during combat operations.

Finally, the last subordinate research question will compare the pre-modification and post-modification data. The third subordinate research question is: Did the field

expedient modifications provide significantly more protection than those vehicles without modifications? Using the answers to this last question, this work will attempt to answer the primary question of the thesis.

The thesis of this work is that the field expedient modifications did not provide significant improvements to the levels of protection to their vehicles in terms of improved performance of the vehicles' basic armor package against traditional antiarmor weapons. High velocity cannons and howitzers comprised the enemy weapons that field expedient modifications did not perform well against. Some of the modifications in this category are sandbagging of the vehicles' exterior, adding spare sections of track blocks and pouring cement over the vehicles' frontal armor. For this study, these modifications will be referred to as modifications to primary protection.

There was one category of improvements, however, that did significantly improve the protection of armored vehicles. This is the category of modifications crews made that prevented or mitigated the effects of close-in infantry attacks against armored vehicles. A few types of modification in this category are the hedgerow busting devices developed during World War II, the addition of infantry phones in several conflicts and the development of rocket propelled grenade (RPG) screens for armored personnel carriers (APCs) during the Vietnam War. For the purposes of this study these modifications will be referred to as modifications to secondary protection.

Despite their failure to improve real effectiveness against the enemy's primary armor killing weapons, field expedient modifications often produced a psychological benefit even if their real worth proved dubious. The psychological impact of field expedient modifications was significant in all three wars under study. The confidence that

modifications promoted in armored vehicle crews justified the time and expense of those modifications. Crews who sandbagged their M4 medium tanks in World War II or added steel airfield runway matting to the sides of their APCs in Vietnam felt more confident that their vehicles would protect them in combat. Confidence in equipment plays no insignificant part in how well, or poorly, crews and units perform in combat.

In order to arrive at a satisfactorily answered thesis, terms and language must be clearly defined. Clear understanding of several terms is necessary to accurately frame the research questions and attempt to reduce ambiguity in the conclusions this work draws.

Field expedient modification is defined as change made after the vehicle has left the production facilities and depots. It is not a change in model, an official upgrade or an evolutionary development of a line of vehicles. A field expedient modification is made in the theater of war, with the materials at hand, using tools and equipment available to crews and units. A few examples of the types of modifications that will be examined are: field phones added to tanks to facilitate tank-infantry communication in close combat; the “Culin Device” and other hedgerow penetrating modifications from the Normandy campaign of 1944; expedient camouflage and paint schemes of armored vehicles; various type of added material (concrete, sand bags, wood, metal, track blocks, road wheels) aimed at reducing effectiveness of enemy systems weapons; addition or modification of machine guns or other weapons; and addition or subtraction of radio antenna and other distinguishing articles. Modification is broadly defined as anything a crew does to improve the protection of the crew and the system to some other state than how it emerged from the production facility.

Modifications considered for this work also include those changes performed by maintenance and support personnel at the tactical unit level. Units often institutionalized changes made to armored vehicles by innovative crews. Tactical headquarters directed and resourced maintenance units to make changes to whole fleets of vehicles. An example of this type of widespread modification occurred in Normandy in the First US Army. Members of the 747th Tank Battalion, attached to the 29th Infantry Division, developed a device to poke holes in Norman hedgerows to allow tanks to penetrate the barriers. First Army adopted the idea and directed the 52nd Ordnance Group to mass produce the devices.³ These larger scale modifications still fall under the realm of field expedient due to the fact that they occurred in the combat zone after the vehicles left the production facilities.

For instance, while this study recognizes the evolution of the M4 Sherman medium tank through a series of upgrades and designations, none of those progressive changes will be considered for its own sake. They were changes to the M4 made in the factory and at the depot. They constitute changes that resulted from research, development and technological advancement throughout the life of the M4 family of vehicles. Changes to the M4 Sherman series that will be examined are those that individual crews and units undertook to improve the protection of their tanks, regardless of which particular model they happened to be operating at the time.

Closely following the refinement of the term field expedient is the importance of clarifying the exact types of vehicles that will be examined in this study. For the purposes of this study the term armored vehicles will be a broad based definition. Any vehicle that was purpose built in the factory with additional armor beyond the normal skin of a motor

vehicle will be included. Examples of World War II systems considered for this study are: all the light and medium tanks produced during the war; armored cars; half-tracks; and tank destroyers. Since America fought the Korean War with much of the same material that it fought World War II, the same broad definition will be used for that conflict. The addition of armored personnel carriers to the military arsenal between the Korean and Vietnam conflicts leads to the addition of those systems to the list of vehicles under consideration for that war.

Additionally, this work will only examine American-made armored vehicles that served in United States Army or United States Marine Corps formations. American-made is defined as designed and produced in the United States. While many American-designed and built armored vehicles saw service in the armies of many nations, the modifications foreign militaries made to American models will not be considered.

The time periods under study must be clearly defined as well. This work will focus on field expedient modifications that US Army Soldiers and US Marines made to armored vehicles during or immediately prior to combat operations. Therefore, the following time periods will be examined: World War II, the Korean War, and the Vietnam War. Combat operations during World War I and the limited combat operations between the two world wars will not be considered in an effort to limit the scope of this work. Operations Desert Shield-Desert Storm will not be addressed by this study for two main reasons. The first is that little evidence exists that American troops executed very few field expedient modifications to armored vehicles. Second, the armored systems employed by US forces during operations Desert Shield-Desert Storm are still being used by American Soldiers and Marines throughout the world. Any discussions of capabilities,

limitations and performance of those systems in an open source document such as this work potentially provides useful information to America's current and future adversaries.

Two of the wars under study, Korea and Vietnam were fought in distinct geographical areas. No further limitations along geographic lines, or theaters of operation, are necessary for this study to impose on those three wars. World War II, of course, was a global war waged in several distinct theaters. For the purpose of this study, there will be no limitation as to particular theaters or geography for World War II.

World War II saw American forces facing several different kinds of enemy threats. When comparing evidence from different theaters, however, this work will consider different operating environments and different enemies. In particular, different enemy weapons systems naturally led to different countermeasures taken by American troops. Evidence from different theaters and different environments will be carefully compared so as not to lead to false conclusions.

There is only one significant assumption that must be made to allow work to proceed. It is necessary due to the fact that, by definition, field expedient modifications to armored vehicles are individual crew or small unit functions. Crews perceive a need to make changes then proceed to make those changes as best they can. Organizations rarely institutionalize modifications above tactical unit level. There are some instances where battalion sized units formalized changes. In the case of the 117th Cavalry Reconnaissance Squadron (Mechanized) during World War II in Europe some modifications became a squadron policy. According to the 117th Cavalry's commander, Lieutenant Colonel (LTC) Kenneth T. Barnaby Jr., the entire squadron modified their M8 armored cars in response to a failing of the M8's belly armor protection from mines. No M8 was allowed

to leave the squadron maintenance shop without an added armor plate on the floor of the driver's compartment.⁴ Often, the modifications units and crews made were limited to the materials and tools they had at hand. Availability of materials and tools are tangibles that can be analyzed and considered. Another key component is the creativity, ingenuity, imagination and mechanical skill of the troops themselves. They are intangible, immeasurable skills. This study will assume a uniform level of those intangible traits for American forces across the four periods in question.

For example, this work will not try to determine if a Marine armored unit in the Central Pacific failed to make effective modifications to its Sherman tanks while an Army tank battalion in France successfully modified its Shermans because the Marines lacked ingenuity or imagination. It is valid to examine the same units' success or failure based on their available tangible resources only.

Discussion of this assumption highlights one potential problem with completing this work satisfactorily. The problem lies in the significant time period under study and the tremendous scope of the wars under examination. World War II alone appears to be a daunting task to analyze. The US Army fielded sixteen armored divisions plus numerous smaller armored formations at the end of World War II.⁵ This work will attempt to remain narrow in focus by looking only at specific documented examples of American crews taking steps to improve the protection of their vehicles. It will not attempt to examine armored operations, vehicle primary armament or any other extraneous matters to the central issue.

Another problem is the amount of literature available for examination. The general material available on the three wars under study and specific material on armored

operations is simply staggering. Coming to grips with the volume of work in existence is a major challenge of this work. There is little focused material, either primary or secondary in nature, on the subject of this work.

The limited amount of writing about field expedient armor protection is, of course, both good and bad for this study. First, it is good because this work hopes to start filling a small gap in the literature of armored warfare. It is difficult because there isn't much of a basis in existence from which to begin writing this study.

There exists copious secondary material on all three wars to provide overall background and general understanding of the conflicts under consideration and how armored forces operated in them. Of particular help is General (Retired) Donn A. Starry's *Armored Combat in Vietnam*. It provides detailed accounts of American armored operations in Vietnam and touches briefly on specific instances of field modifications to armored vehicles. The only problem with the work is that only the undocumented, non-annotated version of the book is available. Both the civilian published version and the Center for Military History published version have no notes or bibliography. According to the Foreword by Brigadier General (Retired) James C. Pennington, a documented, footnoted copy is on file at the US Army Center for Military History.⁶

A series of secondary sources that has proven invaluable is the encyclopedic volumes by R. P. Hunnicutt that lay out in excruciating detail the development, fielding and employment of American armored vehicles. His numerous works provide excellent understanding in the technical details of armored vehicle development for all three wars under study. Like GEN Starry's work, they delve into some areas of field expedient

developments. Both are filled with useful, detailed photographs of both modified and unmodified tanks as well.

One periodical publication provides a wide array of material. *The Cavalry Journal*, *Armored Cavalry Journal* and *Armor Magazine* (as it has been titled over time) provided no less than twenty-five articles that apply to the subject of this thesis. The benefits of the material are threefold. First, there are many first hand accounts of armored operations from all three wars. Next, there is a considerable amount of secondary analysis of armored operations. Lastly, several articles have yielded excellent bibliographies for further study.

The final set of material is the large sampling of primary-archival material that the author has unearthed at the Combined Arms Research Library. This material is where the primary research question will be answered. Again, after brief research, several valuable documents have emerged. The first is a detailed report from the Pacific Theater of Operations (PTO) of observations of various armored battalions across a range of topics. The “United States Army Forces in the Far East Board Report Number 299: Comments on US Tanks, Equipment and Organization” which asked such questions as: “Has the vision cupola been used? Is the vision satisfactory? Do the glass blocks and armor plate provide sufficient protection?”⁷ and then went on to list the answers from four tank battalions and one tank company operating in the Pacific in 1944. This document and others that are certainly in existence should help answer the primary research question.

⁷Isacc D. White, “A Report on United States vs. German Armor” (Headquarters, 2nd Armored Division, 20 March 1945, Exhibit 3, p. 5); reprinted in Command and Staff Department, US Army Armor School, “Military History, Supplemental Material, Technology” (Fort Knox, KY: US Army Armor Center, 1983).

²Ian V. Hogg. *Armour in Conflict, The Design and Tactics of Armoured Fighting Vehicles* (London: Jane's Publishing Company, Limited, 1980), 26.

³James D. Sams, "Ordnance Improvisation in the Combat Zone," *Military Review* 28, no. 2 (1948): 32.

⁴Kenneth T. Barnaby Jr., "Face-Lifting A Cavalry Squadron," *Armored Cavalry Journal* 55 no. 4 (1946): 8.

⁵Donn A. Starry, *Armored Combat in Vietnam* (Indianapolis: The Bobbs-Merrill Company, Inc., 1980), 3.

⁶*Ibid.*, iii-iv.

⁷James A. Callender, "United States Army Forces in the Far East Board Report Number 299: Comments on US Tanks, Equipment and Organization" (Headquarters, United States Army Forces in the Far East, 16 May 1945), 14-15.

CHAPTER 2

WORLD WAR II

Our tanks' armor does not withstand German direct fire weapons of 75-millimeter HV [High Velocity] and larger with the result that in a head on, one tank against one tank fight ours almost always comes out as a casualty.¹

COL S. R. Hinds, "A Report on United States vs. German Armor"

The above quotation from the commander of Combat Command B, 2nd Armored Division, in the spring of 1945 sums up the primary reason many armored vehicle crews resorted to field expedient modifications to improve the protection offered by their mounts. The simple fact is that, in Europe, US armored vehicles did not offer adequate armored protection from most German antiarmor weapons systems. Major General I.D. White, commander of the 2nd Armored Division, wrote in a letter to General Dwight D. Eisenhower that if it were possible to have such a choice, he "would prefer to fight in the present German Mark V or VI tank against the present US medium tank and tank destroyer with the 90-millimeter gun."² White's comments reflected a common feeling among American armored crewmen. US mechanized soldiers felt that their equipment lacked sufficient protection from enemy fire. The Americans were correct. The lack of adequate protection forced American troops to find methods to improve their vehicles' protection.

US Equipment

Before analyzing the field expedient modifications that US forces made to their vehicles it is necessary to briefly describe their vehicles. The US military fought World

War II with vehicles that could be broken down into four general categories. They were: medium tanks, light tanks, tank destroyers and armored cars.

Medium tanks comprised the vast bulk of tanks that saw combat under the American flag during World War II. The United States began World War II with one medium tank, the M3, in full production and one medium tank, the M4, in development. Production of M4 medium tanks began in February 1942.³ The M3 medium tank, called the General Grant by the British and the General Lee by the Americans, began full production in the summer of 1941.⁴ The Grant-Lee mounted a 75-millimeter gun in the hull and a 37-millimeter gun in a small turret. The British and other Commonwealth forces used the M3 medium tank extensively in North Africa and the Pacific but the Americans only employed the tank for a short while during the North African campaign. The Grant-Lee was quickly phased out of the American arsenal in 1942 and 1943 and declared obsolete in April 1944.⁵ The M4 medium tank, the Sherman, replaced the M3 Grant-Lee starting with operations in North Africa.

Full production of M4 medium tanks began between February and July 1942.⁶ America produced 46,732 M4 series medium tanks between February 1942 and June 1945.⁷ US manufacturers built thirteen variations of the basic Sherman tank and twenty--two other types of specialty vehicles based on the M4 medium tank chassis.⁸ The following statistics cover the range of key characteristics across the many variants that were produced. The M4 medium tank series weighed between 66,000 and 73,400 pounds. The M4s produced a maximum speed of twenty-five to thirty-miles-per-hour on roads with a cruising range of 100 to 150 miles. The Shermans mounted either a 75-millimeter or 76-millimeter gun in the vast majority of models. All Shermans carried a bow-

mounted .30-caliber machine gun and a coaxially mounted (mounted alongside the main armament) .30-caliber machine gun. Most Shermans also mounted a .50-caliber machine gun in a swivel mount on top of the turret.⁹

Protection was the area of M4 medium tank performance that crews found lacking the most. The commander of the 67th Armored Regiment from the 2nd Armored Division generalized about Sherman protection by saying, in the spring of 1945, that US armor was “insufficient to prevent penetration by high velocity ammunition used by German tanks and antitank weapons.”¹⁰ That characterization held true across all the variants of M4 medium tanks employed in combat. Later models offered better protection than models produced earlier in the war but crews were uniformly critical of the Sherman’s capacity to defeat German arms. Earlier versions of the Sherman carried two inches of armor on the hull front and three inches of armor on the turret front.¹¹ As the war progressed levels of protection slowly increased but never enough to improve the troops’ confidence in the protection of their tanks. One version of the Sherman, the M4A3E2 assault tank, utilized four inches of armor on the hull front and six inches of armor on the turret front. This tank demonstrated significant survivability against German systems, but only 254 of the M4A3E2 series were ever produced.¹² By comparison, early models of the German Panther tank (the workhorse of German armored forces from 1943 to 1945) began life in 1943 with 3.15 inches of armor on the front. The Germans slowly increased armor to nearly five inches by the end of the war.¹³

The Americans also fielded tanks categorized as light tanks. Like the medium family of tanks, the US began the war with one type of light tank in service and others in development. Again, like the medium tanks, each basic type of light tank (M3, M5, and

M24) was constructed in a series of improved and changed versions. The US began the war with the M3 light tank in service. It weighed fourteen tons and mounted a 37-millimeter cannon. The M3 light proved fast and maneuverable but lightly armored.¹⁴ Although the British favored the M3 light tank, it was quickly declared obsolete and superseded by the M5 light tank.

Production of the M5 light tank began in June 1942 based upon modifications and improvements from the M3 light tank.¹⁵ The M5 light tank incorporated an improved engine but still mounted a similar weapon and armor. Production ended in June 1944, when the new M24 Chaffee light tank began to reach the field. German tanks of all types outclassed the M5 light tank. Major General White proclaimed that “the M5 light tank is obsolete in every respect as a fighting tank.”¹⁶ The M5 light tank did, however, remain in service throughout the war in all theaters of operations.¹⁷

Manufacturers in the US produced 4,070 M24 Chaffee light tanks between April 1944 and June 1945. The M24 incorporated the speed and maneuverability of the M3 and M5 light tanks, as well as the other light tanks’ light armor protection. The M24 carried armor no greater than one inch. The incorporation of a high-velocity 75-millimeter gun into the M24 light tank’s design was the most significant change in the Chaffee tanks.¹⁸ The commander of the 82nd Reconnaissance Battalion in Europe in 1945 commented that: “The unanimous opinion of experienced tank crews and commanders [was] that the M24 has all the desirable features of any German light tank as well as many not incorporated in the German light models.”¹⁹ The M24 Chaffee saw only limited service in Northwest Europe and the Pacific at the end of World War II.

Three types of self-propelled tank destroyers filled the US inventory during World War II. The Army intended them to be fast moving, lightly armored, and powerfully gunned armored vehicles designed to counter enemy armored threats. Designers married an open topped turret carrying a three-inch antiaircraft gun to an M4 medium tank chassis to create the M10 tank destroyer. The resulting vehicle combined the positive aspects of the M4 Sherman's mechanical reliability and maneuverability with the negative aspects of M4 medium tank protection vulnerability in the hull. The open top and extremely thin armor of the M10 turret proved to be extremely vulnerable to all types of enemy fire. Army planners always intended the M10 tank destroyer to serve as an interim vehicle until a purpose built and designed tank destroyer became available. The M10 served in large numbers in Europe throughout the war, however, and was roundly criticized as being too lightly armored and too lightly gunned. Late in the war the US Army replaced the three-inch gun in the M10 tank destroyer with a high velocity, 90-millimeter antiaircraft gun to create the M36 tank destroyer. The increased firepower capability did not arrive in the European theater with any significant increase in protection. While the M36 was an improvement over the M10 tank destroyer it still suffered from chronic lack of armor.²⁰

The only armored vehicle purposefully designed as a tank destroyer from the ground up was the M18 Hellcat. Weighing less than twenty tons, the M18 combined fifty-mile-per-hour speed with an improved suspension. Crews roundly applauded the Hellcat's maneuverability. Designers mounted a 76-millimeter, high-velocity gun in the open topped turret of the M18. Like the M10 and M36 tank destroyers, the M18 Hellcat left significant room for improvement in protection for the crews. Tank destroyer crews

throughout the European war made significant field modifications to improve the primary protection of all three types of tank destroyers. The US fielded only two types of armored cars during World War II. Most of the armored cars equipped reconnaissance organizations in combinations with light tanks and unarmored wheeled vehicles. The more important of the two armored cars was the M8 armored car which was referred to as the Greyhound.

American industry produced only 8,523 M8 Greyhounds during the war. The six-wheeled, six-wheel-drive M8 afforded little protection with only .75 inches of armor in the hull and turret of the vehicle and .13 to .25 inch of armor plate in the vehicle belly. The open topped turret mounted a 37-millimeter gun and .30-caliber machine gun. An additional provision for a .50-caliber machine gun mounted in a flexible mount on top of the turret was available.²¹

The M20 armored car used the exact same chassis and mechanical layout as the M8 armored car but did not mount a turret. Instead of the turret, the M20 possessed a square built-up area in the center of the vehicle. Within this built-up area, a circular weapons ring carried one .50-caliber machine gun. M20 armored cars most often found use as command and control and logistical vehicles alongside M8 Greyhounds in reconnaissance formations.²²

The Axis Threat

American armored crewmen in Europe faced a four-faceted threat from German forces. German tanks, antitank guns, and self-propelled guns formed the most deadly set of threats to US armored vehicles. This German capability posed the most serious threat to all types of US armored vehicles. German systems generally outclassed US vehicles in

terms of range, accuracy, and armor-penetrating power. German forces proved efficient at camouflaging and positioning their antitank guns. An Army Ground Forces observer who wrote a report detailing armored operations in Europe in 1944 commented that: “A good rule of thumb [for tank crews] is to figure that wherever they [antitank guns] should be is generally where they are.”²³ The threat of German tank and antitank gunfire drove most of the primary protection modifications that US soldiers devised in Europe.

The second greatest threat to US vehicles came from German handheld antiarmor weapons, such as the *panzerfaust* and *panzerschreck*. The *panzerfaust* was a small weapon with a short range and enormous penetrating power. An ordnance officer from the 3rd Armored Division conducted tests with a *panzerfaust* and found that it could penetrate the turret armor of a German Royal Tiger tank.²⁴ A common soldier could employ the device with minimal training.

The Germans copied and enhanced the American designed antitank rocket launcher, commonly referred to as the “bazooka,” to create their own bazooka, the *panzerschreck*. The *panzerschreck* demonstrated, like the *panzerfaust*, significant ease of use and became ubiquitous on the European battlefield. According to a soldier who encountered the *panzerschreck* it “could drill through the turret armor of a M4 [Sherman] tank.”²⁵ The 17th Armored Engineer Battalion conducted tests against German tanks and found that the *panzerschreck* penetrated Panther tanks at ranges of up to 200 yards.²⁶ The effectiveness of the *panzerfaust* and *panzerschreck* led to several of the secondary protection modifications that US crews developed during World War II. The intent of these adaptations was to prevent German infantry from getting close enough to American vehicles to employ their hand-held antiarmor systems.

Enemy artillery and mortar fire constituted the third category of threat to US armored vehicles in Europe. Observers noted that: “Tanks invariably draw artillery and heavy mortar fire and any display of tank strength will cause the enemy to open up with everything he has.”²⁷ American light and medium tanks generally survived the blast and shrapnel effects from mortar and artillery fire that did not strike the vehicles directly. Enemy indirect fires did, however, lead to primary armor modifications by US crews.

Mines also posed a significant threat to US armored vehicles. The Germans used several varieties of antipersonnel and antiarmor mines. While M4 Sherman tanks were somewhat susceptible to mines, the mine threat posed a serious challenge to American light tanks, tank destroyers and armored cars. Some crewmen devised field expedient modifications to defeat the mine threat.

In the Pacific theater of operations armored vehicle crewmen faced the same four general categories of threat that American forces faced in Europe. The Japanese, however, fielded vastly fewer tanks and self-propelled guns. The tanks they fielded posed no significant threat to US forces, although the Japanese did use antitank guns in significant numbers. One type in particular, the 47-millimeter, high-velocity antitank gun, proved deadly to both Army and Marine crewmen. The 47-millimeter gun would penetrate the M4 medium tank in any area except the glacis plate.²⁸ Traditionally, emplaced mines and indirect fire also posed threats to US vehicles.²⁹ Soldiers and Marines searched for expedient methods to reduce the Japanese threats just as Army crewmen did in Europe.

The most significant difference in enemy threat from the Pacific to Europe evolved from differences in German and Japanese antiarmor tactics. With some

variations, the Japanese employed infantry in direct attacks against armored vehicles with satchel charges, magnetic mines, regular mines, and in some cases, explosives strapped directly to soldiers' bodies.³⁰ The Army's 193rd Tank Battalion noted a pattern of Japanese infantry attacks in 1944 on Okinawa. Japanese squads of three to nine men attacked individual tanks. Each man in the squad filled a role. One man threw smoke grenades to blind a targeted tank. The next man threw fragmentation grenades to force the tank's crew to close their hatches. Another man placed a mine on the tank's track to immobilize it. A final man placed a mine or explosive charge directly on the tank to attempt to destroy the tank.³¹ These direct assaults by Japanese infantry forced crewmen in the Pacific to develop some unique modifications to combat the Japanese threat.

World War II Improvisations

Field expedient modifications fell into two broad categories during World War II. The first category consisted of modifications made that attempted to increase a vehicle's capacity to resist enemy fire. This primary protection usually sought to increase the thickness of American vehicles' armor. Crews added sandbags or other barrier material to correct perceived deficiencies in their vehicles' protection. The second category of modification encompassed modifications that improved a vehicle's protection by means other than simply adding more material to the existing armor. Some examples of these changes included paint and camouflage, addition of devices to communicate with infantry on the ground, and fabrication of devices designed to penetrate barriers.

Addition of simple sandbags served as the most common type of improvement in primary protection that crews and units made. Crews executed many variations of a common theme, but in general, they found ways to arrange layers of sandbags on the

front, sides, and turrets of their armored vehicles. Initially, crews simply stacked sandbags on their vehicles and secured them with any available material. Common ways of keeping the sandbags in place included chicken wire and communications wire. Later, units added welded metal bracket systems to hold the sandbags in place.³² Crews added anywhere from a few haphazard sandbags on the front slope of a vehicle to nearly 200 bags in some cases. According to the commander of the 3rd Battalion, 67th Armored Regiment, “Tank crews in this battalion are adding sandbags to their tanks, about 170 bags for each tank, in an effort to make up for the tanks’ lack of armor and the penetrating ability of German guns.”³³ The 14th Armored Division as a whole systematically sandbagged their tanks prior to entering combat.³⁴

Opinions on the effectiveness of sandbagging tanks proved divided. The 3rd Armored Group tested a *panzerfaust* against a M4 Sherman on 28 July 1944. As a result of the test trucks drove back to the landing beaches the next day to acquire more sand.³⁵ Sergeant Joseph O. Posecoi, a tank gunner from 2nd Armored Division, expressed his opinion this way: “If our tanks aren’t out armored and outgunned, why does every outfit that has ever been up against a German Mark V [Tiger] tank use 100 to 150 sandbags for added protection?”³⁶ A final positive example of the effectiveness of sandbags came from Technical Sergeant Richard T. Heyd of the 2nd Armored Division. He stated in 1945 that: “Of a total of 19 tanks hit, 17 tanks had been penetrated while only 2 tanks had withstood the force of the enemy high velocity shells and ricocheted the projectiles. These ricochets were due to the added protection of sandbags and logs used to reinforce the armor plate in front of the tank.”³⁷

United States Marine Corps tank crews also devised effective ways to use sandbags to protect their vehicles. The Marines layered sandbags over engine covers and rear decks to fight Japanese attacks with satchel charges and thrown antitank mines.³⁸

Despite wide approval of the practice, there were also dissenting opinions. Technical Specialist 4 William J. Marcheski described an encounter with a German Tiger tank in 1945 where the German tank destroyed two M4 medium tanks by penetrating multiple layers of sandbags and then the tanks' organic armor with catastrophic results.³⁹ Other negative opinions against sandbagging resulted from the effects that the added weight had on vehicles. The 117th Cavalry Reconnaissance Squadron abandoned the practice of sandbagging its armored cars and light tanks because the benefit of the limited additional protection did not outweigh the damage that the added weight caused to the squadrons' vehicles' suspensions and drive trains.⁴⁰

Sandbagging did significantly improve the overall effectiveness of vehicle armor against enemy weapons such as *panzerfausts* and *panzerschrecks* as well as mines, mortar fire and artillery fire. At the very least the sandbags reduced the munitions' effects even if they did penetrate the sandbags and organic armor of a vehicle. Adding sandbags to armored vehicles did not significantly reduce the effectiveness of enemy fire from tanks, self-propelled guns and towed antitank guns. Exceptions to each generalization did occur, of course. Sergeant Heyd's experience demonstrated that sometimes sandbags were effective in protecting American armored vehicles.

Another field expedient technique that American crews used to increase the primary protection of their vehicles borrowed a material long used in the construction of fixed fortifications: cement. The use of cement occurred in two variations. Crews mixed

cement in the traditional way, then poured it over the front slopes of their Sherman tanks. In tests conducted by the 709th Tank Battalion in February 1945 German *Panzerschreck* antiarmor rockets penetrated the concrete and the tank's skin. The concrete, however, reduced the effectiveness of the German warhead inside the tank. According to the 753rd Tank Battalion, poured concrete reduced the danger of the crew being killed even if the tank was destroyed. The use of concrete became widespread enough that members of the 750th Tank Battalion spent hours with jackhammers removing up to six inches of concrete from their vehicles when they prepared to turn in their M4 medium tanks at the end of the war.⁴¹ Marine Corps crews from C Company, 4th Marine Tank Battalion expanded the concrete modification to extreme levels. The Marines fitted two inch by twelve inch wooden planks to the sides of their Shermans with four inches of space left open between the planks and the sides of the tanks. The Marines poured concrete in the void. They wanted the concrete to defeat Japanese antitank guns and the wooden planks to defeat magnetic antitank mines. Forces in the Pacific found "that canvas or neutral materials applied on the tanks made the magnetic mines slide off."⁴² The modifications proved effective in adding protection to the tanks but the added weight often caused problems transporting the vehicles in Navy transport craft.⁴³

Marine Corps tank crewmen in the Pacific responded to the unique nature of the Japanese methods of antitank warfare in some unusual ways. In order to prevent direct contact with tank hatches by hand emplaced mines and explosive charges, the men of C Company, 4th Marine Tank Battalion, mounted steel mesh cages on hatch covers. Additionally, some Marine units welded common nails, with the pointed end up, to the

tops of their turrets and other surfaces of their tanks. The intended effect was to impale Japanese troops attempting to destroy American tanks from extremely close range.⁴⁴

In some cases, armored vehicle crews did not have to look far for material to attempt to improve the armor of their vehicles. A solution widely used in World War II was the mounting of sections of spare track on the vehicles' exteriors. Most tracked vehicles carried sections of usable track from the outset of the war for mechanical reasons. Crews needed spare track blocks available in case their track failed mechanically or received damage from enemy fire. Crews quickly realized that the spare track, when mounted in critical locations, provided some measure against enemy kinetic armor piercing ammunition. Against shaped charge weapons like the *panzerfaust* the track section added standoff protection to defeat or reduce the effects of the enemy warheads. The 1st Armored Division in Italy employed long sections of track attached to the front of their Sherman tanks.⁴⁵ In the Pacific, Ordnance Corps crews welded steel track on sponsons, turrets and glacis plates to reduce the effectiveness of the highly effective Japanese 47-millimeter high velocity antitank guns.⁴⁶ Armored forces widely made this modification with many different variations in all theaters during the war.

Many crews and units exercised a variation on the technique of adding track blocks to armored vehicles. They added more metal to critical areas of their mounts to improve the performance of the armor. The US Army recognized the inadequate protection of the M4 medium tank even before the tank entered combat. The Americans systematically welded one inch steel plates over sensitive ammunition compartments. While this change to the basic design of the M4 medium tank was not field expedient, it

demonstrated a weakness in the basic protection of the Sherman. Crews quickly adopted expedients to carry the addition of armor to new levels.

At Anzio, Italy, in 1944 US forces encountered a long stalemate characterized by significant artillery duels. Tank destroyer battalions welded armor plate over the radiators of their M10 tank destroyers to protect them from artillery and mortar fragments.⁴⁷ Units in different operational environments conducted similar modifications. Ordnance crews cut armor plate from destroyed vehicles to upgrade the armor on M4 medium tanks during the island campaigns in the Pacific.⁴⁸ A 2nd Armored Division crewman described how 1.5 inches of armor added to his M4 medium tank stopped a German cannon round: “The fifth shot hit the extra armor plate welded to the front plate in front of the of the bow gunner, about 1 1/2 inches thick, and knocked that off and cracked the front plate.”⁴⁹ The key point is that the shot did not penetrate the tank. On that particular day the effort the crew expended to make a field expedient modification proved worthwhile.

Crews and units did not always view modifications the same way. Often the differences of opinion resulted from different operational environments. In the 117th Cavalry Reconnaissance Squadron in Europe no light tank or M8 armored car was allowed to leave the squadron maintenance shop without a steel plate added to the floor boards underneath the driver.⁵⁰ Units surveyed during the fighting on Leyte in the Philippines reported adding no additional armor to their light tanks.⁵¹

The Hedgerow Problem

The second broad category of modifications encompassed changes that improved a vehicle’s protection by means other than simply adding more material to the existing

armor. Often the changes involved preventing or mitigating the effects of close infantry attacks on armored vehicles. Along those same lines, improving cooperation with friendly infantry forces frequently led to modifications conducted by armored vehicle crews.

The category of devices developed in June and July 1944 to combat the hedgerows encountered by American forces in Normandy were the dominant example of field expedient modifications that US forces employed during World War II to improve the secondary protection of their vehicles. The reason that US units needed to make modifications is that they arrived in Normandy totally unprepared for the type of terrain they faced.

Norman farmers enclosed their pastures, fields and orchards for hundreds of years prior to the Americans' arrival. Most fields measured only several hundred square meters. Over the years, the hedgerows developed and expanded to form a complex system of barriers broken only by a small opening to allow entry into the fields at one point. Independent tank battalions supporting the infantry in Normandy quickly learned the limited openings and entry points into the fields beyond the hedgerows usually had antitank guns or infantry antiarmor weapons targeted there.⁵² At the base of each hedgerow, a mound of earth and rock one-to-four-feet wide formed the base of the barrier. On top of this mound grew trees, vines and hedges giving the total hedgerow a height of between three to fifteen feet. Additionally, hundreds of years of use caused the roads between the hedgerows to develop a sunken effect; the surface of the road was lower than the surface of the surrounding fields. Due to all these factors, the hedgerows

afforded excellent cover and concealment for defensive forces and significant obstacles to offensive forces.⁵³

The hedgerows tended to constrict armored vehicles to roads and trails while reducing visibility to extremely short ranges. Additionally, the hedgerows provided excellent concealment for German antiarmor guns and hand-held antiarmor weapons such as the *Panzerfaust*. The Germans could concentrate their antiarmor systems on the few available roads and open areas. The Americans initially suffered high loss rates in armored vehicles when they stuck to the roads. One armored division lost twenty-seven tanks in one operation around St. Lo alone.⁵⁴ The crewmen eventually realized the need to get through the hedgerows for two reasons. The more important was the need to get off the roads to increase the chances of their own survival. The second was to do their assigned job of supporting the US infantry. The same characteristics of terrain that led armored vehicle crewmen to avoid the hedgerows attracted the infantrymen. American tankers found that they could drive over most of the hedgerows with their M4 medium tanks. However, driving over the hedgerows exposed the relatively soft underbelly of the tanks to enemy fire and also prevented the crews from bringing the tanks' weapons to bear on the enemy in the first critical seconds as the tank entered a field. So, beginning in the middle of June 1944, American forces began searching for means to break directly through the hedgerows.⁵⁵

One solution to the problem already existed. Each American tank battalion supporting an infantry division possessed four Shermans modified at the factory to mount a bulldozer blade. The dozer tanks proved very effective in busting the hedgerows but far too few existed in 1944 for them to have significant effect. First US Army requisitioned

278 more dozer tanks in July 1944 but they arrived too late to have significant impact on the fighting in Normandy.⁵⁶

The way the Americans sought to solve the tactical problem of the hedgerows was illustrative of the general characteristics of US field modifications to armored vehicles. The first is the decentralized nature of the process. Separate crews and units in Normandy recognized the problem simultaneously. Within their realm, many units attempted to solve the dilemma. The different organizations and crews developed solutions that eventually spread across the battlefield. A second characteristic is the mechanical ingenuity demonstrated by US forces. As a generalization, American soldiers demonstrated a greater familiarity with modern mechanized machinery than their opponents in Normandy. The typical American soldier was more familiar with vehicles, engines and tools than the typical German soldier. Even if American soldiers did not have experience with motor vehicles prior to their Army service, they were quickly immersed in a nearly totally mechanized Army soon after induction. A large proportion of the German Army still utilized horse drawn transportation.

One of the first attempts at creating a device to break through the hedgerows occurred in the 747th Tank Battalion supporting the 29th Infantry Division. At first, combat engineers from the 121st Combat Engineer Battalion placed twenty-four pound explosive charges near the hedgerows to blow a gap for vehicles and infantry forces. Units found that the twenty pound charges often were not effective and increased the size of the charge to fifty pounds. The fifty pound charges proved effective but exposed the engineers to enemy fire and proved very costly in terms of time and logistical support required for the expenditure of demolitions required. The engineers next tried digging

holes into the earthen bases of the hedgerows, then placing the explosives in the hole before detonation. This proved effective but again exposed the engineers. Additionally, digging with hand tools in the tough hedgerow bases proved difficult at best. The next step involved the first real modification to armored vehicles in the process. Crews of the 747th Tank Battalion welded two steel pipes to the front of their tanks. The crews used the pipes to poke holes in the bases of hedgerows for the engineers to insert explosives. The pipes proved extremely effective in creating holes for demolitions and significantly reduced the amount of time engineers were exposed to fire while placing the demolitions.⁵⁷

Crews from the 747th Tank Battalion discovered that sometimes, in the course of punching holes for explosives, they pushed straight through the entire hedgerow. This development negated the need for explosives entirely. Maintenance crews working with tank crews tried making heavier bumpers from sections of railroad track to push through the hedgerows. The system worked so well that other units including the 703rd Tank Battalion supporting the 4th Infantry Division adopted the device developed by the 747th Tank Battalion.⁵⁸

Other units developed similar devices concurrently with the 747th Tank Battalion. A maintenance sergeant in the 102nd Cavalry Reconnaissance Squadron of the 2nd Armored Division responded to requests from tank crews for a device to cut through the hedgerows. Sergeant Curtis G. Culin developed a device fashioned from metal recovered from a roadblock. In basic function the “Culin Device” acted in the same way as the modification created by the 747th Tank Battalion. Culin’s invention garnered the attention of General Omar Bradley, First United States Army Commander in Normandy.

Bradley directed the mass production by consolidated ordnance assets of Culin Devices. From 14 to 25 June 1944 maintenance teams created over 500 copies of the Culin Device. By late July 1944, over 60 percent of First Army M4 Shermans mounted a Culin Device or a similar adaptation.⁵⁹

The success of the hedgerow busting devices illustrated how American forces solved problems of protection for their armored vehicles. An officer who commanded armored forces in World War II commented after the war that: “All those who commanded Armor during World War II can recall many incidents where improvisations, made possible by fertile minds, paid enormous dividends.”⁶⁰ The hedgerow busting devices provided the only example where American forces in Europe institutionalized field expedient modifications across a large cross section of forces. First Army’s centralized production of Culin Devices proved effective but must be considered in terms of the close, restricted proximity of units in Normandy before the breakout occurred after Operation Cobra. Later in the war, American forces fought a widely dispersed, fast paced war that prohibited centralized control.

Field Telephones

One of the most common problems encountered by US armored vehicle crewmen during World War II was a systematic lack of good armored vehicle to infantry coordination and cooperation each time a new infantry unit or armored unit entered combat for the first time. In both the Pacific and the European theaters new units habitually suffered from poor understanding of how armored and infantry units needed to work together. Following the war, the after action review of the 12th Army Group Armored Section vastly understated the problem when it stated that infantry-tank training

in the United States prior to the war was “inadequate.”⁶¹ Problems with infantry-tank communication drove one of the most wide-spread field modifications American forces made to their vehicles. The simple addition of field phones provided a quantum improvement in the secondary protection afforded to crews. By finding ways to talk to soldiers on the ground, crewmen reduced the effectiveness of enemy infantry attacks against armored vehicles.⁶²

As early as the Bougainville Island battles during the Solomons Campaign in 1943-1943 crews began making modifications to facilitate coordination between tanks and infantry. Many units devised slightly different variations of the technique but the way the XIV Corps units made the modifications illustrates the basic concept. Armored vehicle crews attached a standard Army field phone to the rear of their vehicles, usually in an empty ammunition can. Then each crew wired the phone into the intercom system of their vehicle. All an infantryman needed to do was pick up the phone to talk to the crew to point out targets or coordinate action.⁶³ In order to use the phone, infantrymen exposed themselves to run up behind the tank to pick up the phone. Some Southwest Pacific units changed the set up somewhat by trailing a long wire from the tank instead having it terminate at a phone mounted on the rear of the tank. This method allowed the infantrymen to grab the wire from a covered position and attach a phone to effect the communication.⁶⁴ American units in Europe created many of the same systems with slight differences as to specific technique. Infantry-tank phones proved to be an effective addition to the protection of armored vehicles.

Camouflage

US troops in World War II took advantage of one of the simplest and most effective techniques available to increase the protection of their vehicles. They modified the paint scheme of the vehicles and also camouflaged them using local materials. Paint, foliage and netting did not, of course, thicken the armor on vehicles or improve the crews' chances of survival if their vehicle was hit by enemy fire. A crew's best means of protection often lay in not being acquired by the enemy. Not being actually hit by enemy fire due to camouflage served as the next best protection for an armored vehicle crew. Paint and camouflage provided an effective way of modifying their vehicles to improve the chances that the crew and the vehicle might survive contact with the enemy.

American armored vehicles of World War II left the factory painted in olive drab green. According to one American officer who fought in North Africa the factory paint was too dark for the average North African terrain. He described a number of expedient techniques for blending a tank's image into the terrain. By simply never washing a vehicle, crews allowed dust and mud to soften the dark green color and better match the countryside. A more semi-permanent method involved mixing crankcase oil with sand and mud and applying it to a vehicle's exterior. The oil acted as a binder to hold the dirt in place and allowed the crews to create patterns that better matched the surrounding terrain.⁶⁵ The commander of the 117th Cavalry Squadron reported using light tan paint splotted with green in irregular patterns to camouflage vehicles in North Africa.⁶⁶ Following the entry of US forces into France in spring 1944, many of the independent tank battalions slowly recognized a need for better camouflage than the factory paint

scheme on their tanks. Starting in July 1944, the tank battalions began applying green and grey-black camouflage to match the summer foliage of France.⁶⁷

American combat forces encountered snow in both the Italian campaign and the campaign in mainland Europe. Combat vehicle crews camouflaged their vehicles by acquiring or making their own whitewash. Lacking whitewash, they often resorted to commandeering white bed linen to drape over their vehicles. Both techniques proved successful in reducing the visible signature of their vehicles.

Another field expedient involving paint took place in the Pacific theater of operations. Crews there responded to the Japanese threat of magnetic antiarmor mines with an attempt to paint their vehicles with antimagnetic paint. On Okinawa in 1945 the Army's 713th Flame Thrower Battalion mixed sand with paint to try to prevent magnetic contact between antiarmor mines and the vehicles' skins. Results were inconclusive because the 713th did not encounter any magnetic mines.⁶⁸ The example illustrates the innovative techniques soldiers attempted to improve vehicle protection.

In addition to changing paint schemes, crews added additional camouflage to make their mounts more difficult to detect and engage. A platoon leader said that his unit used natural foliage and changed it each day. As a result of this good camouflage discipline he stated that "we drew very little fire from the enemy."⁶⁹ Various units used other inventive techniques to camouflage armored systems. Soldiers from the 1st Armored Division in Italy strung chicken wire on supports to hold multiple layers of vegetation.⁷⁰

Other Modifications

The US Army did not standardize any of these techniques or procedures. Crews took the initiative to understand their environment and then took steps to make their vehicles as difficult a target as possible for the enemy to acquire and engage. Camouflage and paint changes, while certainly not decisive in any form, did improve the overall protection of armored vehicles in World War II.

Armored vehicle crews sometimes added additional weapons to their vehicles' basic armament. While these alterations could have been characterized as field expedient *firepower* modifications, they also increased the *protection* of armored vehicles as well. Additional armament provided close-in secondary protection against infantry attacks. Many units added or changed the way they mounted their crews served machine guns. The most noteworthy adaptation, however, occurred in the Solomon Islands in 1943. Marine armored crews there wanted better protection from Japanese infantry attacks. As a way to better protect themselves, they tried mounting the infantry's flamethrowers on their light tanks. They attached the flamethrower nozzle to the bow machine gun of their light tanks and operated the system from inside the bow machine gunner's position. The results were poor but Marines continued the practice until the Navy and Army industrial base provided purpose-made flamethrowers to mount in armored vehicles.⁷¹

United States armored forces, both Marine Corps and Army, fought the war in vehicles whose protection did not meet the challenge of the enemy's antiarmor capability. A few statistics illustrate the numbers of vehicles that US forces lost during the war. In Europe the 4th Armored Division suffered thirty-six M4 Shermans, ten light tanks and two M18 Hellcats destroyed in the month preceding the Battle of the Bulge.⁷² Between 6

June 1944, and 8 May 1945, the 743rd Tank Battalion, which had fifty-nine M4 medium tanks when it was at 100 percent strength, had ninety-six M4 Shermans destroyed by German forces.⁷³ A single Japanese 47-millimeter antitank gun destroyed four medium tanks from the 193rd Tank Battalion on a single day in April 1945.⁷⁴ The numbers proved that American armored vehicles suffered from a lack of protection.

This lack of protection led individual crews and units to seek ways to improve the protective qualities of their mounts. Using materials at hand US crewmen fashioned innumerable modifications. Some of the field modifications worked. The hedgerow busting devices created during June and July 1944 in France proved their mettle by restoring tactical mobility to armored forces and increasing the protection of the tanks and tank destroyers the devices were fitted to. Some of the field modifications did not work. The Marines experiments with attaching man-portable flame throwers to tanks proved mostly useless. A few of the field expedients provided mixed results.

Sandbagging of tanks in Europe significantly reduced the threat from German hand-held *panzerfaust* and *panzerschreck* antiarmor systems. Against traditional German antitank guns and tanks, however, sandbagging offered little benefit except for psychological benefit for crews. Sandbags made crews feel more confident so there was some positive effect even when crews faced German tanks and antitank guns.

¹Isacc D. White, "A Report on United States vs. German Armor" (Headquarters, 2nd Armored Division, March 20, 1945, Exhibit 2, p. 1); reprinted in Command and Staff Department, US Army Armor School, "Military History, Supplemental Material, Technology" (Fort Knox, KY: US Army Armor Center, 1983).

²Ibid., Exhibit 2, p. 9.

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- ⁴Ibid., 52.
- ⁵Robert S. Cameron, "Armor Combat Development 1917-1945," *Armor* 106, no. 5 (1997): 16.
- ⁶Hunnicut, *Sherman*, 124, 131.
- ⁷Steven J. Zaloga, *The M4 Sherman at War, The European Theatre, 1942-1945* (Hong Kong: Concord Publications Company, 1994), 3.
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- ⁹Ibid., 538-551.
- ¹⁰White, I. D., "Report on US vs. German Armor," Exhibit 2, p. 2.
- ¹¹Hunnicut, *Sherman*, 538-551.
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- ⁵²“Immediate Report Number 27, Report of Armored Section, Headquarters, Twelfth Army Group, Notes on Separate Tank Battalions” (Headquarters, Twelfth Army Group, 14 October 1944), 2.
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⁶⁰Paul M. Robinett, "Armor's Engineer Problem," *Armor* 62, no. 6 (1953): 36.

⁶¹"12th Army Group Report of Operations (Final After Action Report), Volume XI, Antiaircraft Artillery, Armored, Artillery, Chemical Warfare and Signal Sections" (Headquarters, 12th Army Group, 31 July 1945), 59.

⁶²The US Army learned some of the lessons of World War II and included an external infantry phone on most of its tanks fielded between the M4 Sherman and M1 Abrams. Designers did not, however, include an infantry phone on the M1 Abrams tank that appeared in the early 1980s. The problem of infantry--tank communication continues to plague the Army in the 21st Century. As evidence was the inclusion of an infantry phone in the Tank Urban Survival Kit (TUSK) that began production and fielding for M1 Abrams series tanks in 2004 as a result of lessons learned during Operation Iraqi Freedom. Among other modifications for the urban environment, the TUSK kit provides a low tech phone just like the modifications made in World War II.

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⁶⁷Yeide, *Steel Victory*, 89.

⁶⁸Mayo, *The Technical Services*, 463.

⁶⁹Ralph W. Hoffman, "Report of Lessons Learned from 1 August 1944 to 31 August 1944, Inclusive, Second Platoon," in "Army Ground Forces Report Number A-187" (Headquarters, Army Ground Forces, Washington, D.C., 9 December 1944), 3.

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CHAPTER 3

THE KOREAN WAR

Following the victories over Germany and Japan in 1945 the United States military entered a period of prolonged reduction in manning, budget and equipment readiness. American armored forces suffered diminished resources along with the rest of the military establishment. From a peak of 28,000 tanks available at the end of World War II, US armored power dropped to only 6,000 serviceable tanks available when the North Koreans invaded South Korea in June 1950.¹ Except in one case, American armored forces fought the North Korean and Chinese armies with vehicles developed during World War II. Even the one exception, the M46 medium tank, was only an upgraded version of a tank developed in 1943. While some new American tanks were developed before the end of the Korean War they never saw action in Korea. The M47 medium tank and M41 light tank appeared on the scene during the period of the war but neither saw service in Korea.²

The United States Army and United States Marine Corps were spared potentially disastrous results of this failure to improve their armored vehicles following World War II by a similar lack of progress by their enemies. Neither the North Koreans nor the Chinese fought the war with significantly improved armored vehicles or antiarmor systems. For these two reasons, the field expedient modifications conducted by US crews followed similar lines as those modifications made by American forces during World War II.

US Equipment

As was the case with World War II, medium tanks made up the largest category of armored vehicle employed by the US during the Korean War. Americans used one model of light tank and no heavy tanks in Korea. Within the medium tank classification three models of tanks were employed. Soldiers and Marines fought with M4A3E8 Sherman, M26 Pershing and M46 Pershing medium tanks.³ The old Shermans made up more than half of the tanks that saw service in Korea. M26-46 Pershing tanks accounted for a smaller proportion of tanks employed while M24 light tanks provided a small presence in the country. Although the numbers varied from month to month, a snapshot taken in February 1952 accurately portrays how US armored units were equipped throughout the war. As of 14 February 1952, there were 509 M4A3E8 medium, 297 M26-M46 medium and thirty-five M24 light tanks operational in Korea.⁴

Not much changed on the M4A3E8 Shermans from World War II until they entered combat in Korea in 1950. The M4A3E8 design dated from 1944 and incorporated an improved suspension and higher velocity 76-millimeter gun than other models of M4 medium tanks produced. In all other respects the M4 medium tanks used remained similar to the tanks used in Europe and the Pacific during World War II. Overall performance of the veteran Shermans proved to be positive. Colonel William P. Withers commanded tanks in Korea. He reported in early 1951 that the M4A3E8 was “superior to the T-34 [Soviet produced North Korean tank] in every tank-versus-tank action.”⁵ Crews and units routinely praised the Shermans’ mechanical reliability and ease of maintenance. This reliability simplified the logistics required to support the armored forces.⁶

United States armored forces operated two other medium tanks in Korea. Both the M26 medium tank and M46 medium tank, like the Shermans, began life during World War II. Design and development work began on the M26 Pershing in May 1943 in response to the evolving threats from German tanks, such as the Mark V Panther and Mark VI Tiger families of tanks.⁷ Production of M26 medium tanks began in February 1944 but only 200 of the Pershings were issued to fighting units in Europe by the end of the war.⁸ The US rushed M26s to the Pacific theater during the Okinawa invasion, but the Pershings failed to reach the battlefield in time to participate in that operation.

The designers of the M26 Pershing addressed several of the major concerns with Sherman tank design. Five men manned the forty-six-ton Pershing. The M26 carried a 90-millimeter, high-velocity gun; a coaxially mounted, .30-caliber machine gun; and another .30-caliber machine gun mounted in the bow of the tank. The tank commander controlled a .50-caliber machine gun mounted on the turret roof for antiaircraft protection. Crews could push their gasoline powered M26 Pershings to thirty-miles-per-hour but suffered from a range limited to less than one hundred miles.⁹ The greatest improvement over the Sherman series of tanks manifested itself in terms of armored protection. M26 medium tanks carried 4.53 inches of armor on the gun mantlet, 2.99 inches of armor on the turret sides and lower portion of the front hull and 3.94 inches of armor on the upper portion of the front hull. This armor package provided significant increases in protection over the M4 medium tanks.¹⁰

Early evaluations of the M26 medium tank focused on the fact that the forty-six-ton M26 used essentially the same engine as the thirty-three-ton Sherman. The underpowered M26 suffered from mechanical reliability problems related to its engine

deficiencies. Design work to improve the power and reliability of the M26 began in January 1948.¹¹ Designers married an improved power plant and transmission with the existing M26 chassis and turret to create the M46 variant of the Pershing tank. In all other respects the M46 medium tank resembled the M26 medium tank.¹² By the time the Korean War broke out 319 M26 tanks had been converted to M46 tanks. Conversion would continue throughout the war and US armored forces continued using both Pershing versions throughout the war.

US leaders that fought in Korea declared that the Pershings were “superior” in combat versus the T34 tanks and SU-76 self-propelled guns they encountered.¹³ Pershing medium tank armor nearly always withstood fire from enemy 76-millimeter and 85-millimeter tank and antitank guns. The 90-millimeter cannon mounted in the M26-M46 proved effective against North Korean tanks as well as field fortifications.¹⁴ There were, however, problems with the Pershing tanks. The M26 medium tanks continued to be plagued by mechanical problems. Many of the problems were attributed to the lack of power in the M26 but some of the problems resulted from the age of the systems. Some of the first M26s to arrive in Korea with the 70th Tank Battalion were hurriedly pulled from monument display pedestals at Fort Knox, Kentucky.¹⁵ They were given a hasty refurbishment and shipped to the Korean Peninsula. It was not surprising, therefore, that the M26 tanks suffered from reliability problems. The upgraded M46 suffered problems associated with a newly designed and produced drive train.

The only light tanks employed by American forces in Korea were, again, born during the World War II era. The 8th Army had no tanks besides M24 Chaffee light tanks for occupation duty in Japan in June 1950.¹⁶ Those light tanks were the first tanks

deployed to Korea to face the North Korean invasion. American armored forces began, and eventually ended, the war with light tanks from World War II. Reports from units engaged in combat with North Korean tanks stated that the Chaffee light tanks had little or no effect against Soviet T-34 tanks. The report recognized that most of the problem with the M24 light tank was that it had not been designed to accomplish the medium tank's mission.¹⁷ Units equipped with M24 Chaffees suffered heavy casualties early in the war. In one example a light tank company from the 78th Tank Battalion lost all but two of its M24 tanks within two weeks of landing in the Pusan Perimeter.¹⁸ The situation changed later when Sherman and Pershing medium tanks began to arrive to fill the medium tank role they were designed for. An observer team sent from the US in August 1950 to assess the employment of armored forces in Korea summed up the M24 Chaffee's shortcomings by declaring "The M24 is not suitable for the tank role but may be employed as a full track reconnaissance vehicle."¹⁹ Following the arrival of the M4A3E8 and M26-M46 medium tanks the role of the M24 light tank became limited to just the reconnaissance function that the observer report recommended for the duration of the war.

Besides the tanks used extensively in Korea, there was one other armored vehicle that saw significant field modification during the Korean War. Like the tanks, the US Landing Vehicle, Tracked, Armored 5 (LVT(A)-5) saw service at the end of World War II and then was employed in Korea. The LVT(A)-5 began and ended production in 1945 as a replacement for the workhorse LVT(A)-4 that both the Marine Corps and Army used for amphibious operations in both theaters of war. Only 269 of the LVT(A)-5s were constructed. Between the wars some LVT(A)-5s received minor modifications to

improve turret ergonomics and other minor aspects of performance. Both the modified and original versions of the LVT(A)-5 saw similar field modifications during the Korean conflict. Following the war, the Marine Corps withdrew the LVT(A)-5 vehicles from service.²⁰

The LVT(A)-5 served as an armed, lightly armored companion to the tracked amphibious troop carriers that US forces employed in wide numbers to land infantry during amphibious operations such as the landings at Inchon and during river crossing operations during the counteroffensive in 1950-1951. The Marines used the heavy fire power of the LVT(A)-5 to support assault troops with direct fire from its main armament as well as in a secondary role as indirect fire support. LVT(A)-5s carried a six man crew in a fully tracked amphibious vehicle. A small turret mounted a 75-millimeter howitzer. On most models three .30-caliber machine guns provided secondary armament. One .50-caliber machine gun replaced one of the smaller caliber machine guns in a few models. Weighing about 40.5 tons, the LVT(A)-5 could reach speeds of sixteen-miles-per-hour on land or seven-miles-per-hour in the water. The LVT(A)-5 protected its crew with very light armor, in no places more than one-half inches thick. The Marines systematically added one-quarter or one-half inch armor plate during pre-invasion preparation to critical areas for added protection. Even with the improved armor the LVT(A)-5 provided limited protection for its crew.²¹

Communist Equipment

By the time the Korean War ended in 1953, US armored vehicle crews faced a significantly different threat than that posed when the North Koreans first invaded South Korea in June 1950. The threat to armored vehicles changed in parallel with the changes

in the basic nature of the war. During the initial stages of the war, the North Korean People's Army invaded with 225 T-34/85 tanks.²² American units fought a mostly defensive fight against North Korean armor until the amphibious landings at Inchon signaled a transition to a general counteroffensive by US and United Nations forces against the North Koreans. As the US forces counterattacked north against North Korean forces, US armored crews found that the North Korean threat changed to defensive tactics employing tanks in static defensive positions and extensive use of antitank guns and hand-held antiarmor weapons such as captured American bazookas and recoilless rifles. By the time the conflict settled into a static war along the 38th parallel during the winter of 1950-51 the threat to US armored vehicles shifted to infantry attacks and some artillery and mortars. Throughout the war mines posed the greatest single threat to US armored vehicles. A study conducted by the Operations Research Office of the Far East Command during the spring of 1951 identified that 38 percent of tank casualties from the beginning of the war through January 1951 were the result of mine strikes.²³ The second highest percentage of loss came from antitank guns at 15 percent.²⁴ The threat of mines grew throughout the war. During the second half of 1951 mines destroyed 270 tanks while antitank guns and infantry antiarmor systems combined destroyed thirty-two tanks.²⁵

The North Koreans, much like the Americans, fought the Korean War with equipment left over from World War II. The only tank they employed in any significant numbers was the Soviet designed and produced T-34/85. When it first appeared on the battlefields of the Eastern Front during Operation Barbarossa in 1941, the T-34 proved an equal match for German armor of the time. Initially the T-34 mounted a 76-millimeter cannon but was later up-gunned to carry a 85-millimeter cannon. The North Koreans

employed 225 of the later model T-34/85 in June 1950.²⁶ Age, wear and tear and the evolution of tank capability left the T-34/85, by June 1950, underarmored, outgunned, and outfought by more modern systems that the Americans employed.²⁷ The only US tanks that proved inferior to the North Korean T-34/85 systems were the M24 light tanks pressed into service in the medium tank role during the early stages of the war. As the war progressed fewer and fewer North Korean tanks appeared on the battlefield. By 1953 American forces reported few contacts with, and nearly zero losses to, enemy tanks.²⁸

The North Koreans used significant numbers of antitank guns against American forces. Engagements between North Korean antitank guns and American armored vehicles became particularly numerous during counteroffensive operations following the Inchon landings and breakout from the Pusan Perimeter. American armored vehicle crewmen received fire from numerous types of antitank guns. At one time or another the North Koreans employed Soviet-made, 45-millimeter antitank, 57-millimeter antitank, 85-millimeter antiaircraft, and even 152-millimeter howitzers against American armor.²⁹ The North Koreans also exploited captured American 37-millimeter and 57-millimeter antitank guns and even Japanese Type 92 howitzers left over from World War II.³⁰ Despite the wide range of types and large numbers of antitank weapons that the North Koreans used, they enjoyed relatively little success against American armor with their antitank guns. For the period 1 July 1950 to 21 January 1951 enemy forces destroyed fifty-six Pershing medium tanks and seventy-six Sherman medium tanks. Out of those total numbers of US tanks destroyed, enemy antitank guns accounted for four Pershings and fifteen Shermans.³¹ Later in the war the numbers remained relatively constant. From

June through December 1951 antitank guns accounted for only eight out of 302 total US tanks destroyed in Korea.³²

In terms of infantry antiarmor weapons and tactics the North Korean and Chinese armies mirrored the Japanese threat encountered by US armored forces in the Pacific theater of operations during World War II. Although the enemy did use some recoilless rifles and rocket propelled grenades against armor, American crews did not face nearly the number of hand-held antiarmor weapons that they did in Europe during World War II. The Chinese and North Koreans, like the Japanese before them, did not possess any significant numbers of tank killing devices like the German *panzerfaust* or *panzerschreck*. The most serious threat posed by infantry antitank weapons to American armor came from US made bazookas captured from the Americans and South Koreans then employed by North Korean and Chinese forces.³³

Due to this lack of antiarmor weapons the North Koreans and Chinese resorted to mass infantry assaults against US tanks. Typically, the enemy would employ massive amounts of small arms fire against tank crews at night to isolate and blind the American crews. Then, enemy soldiers would attack the tanks with explosive pole charges or satchel charges to destroy or disable the tanks. This type of tactic became particularly prevalent once the front line stabilized along the 38th Parallel and US armored crews found themselves employed in static defensive positions dispersed across isolated hilltops in support of defending infantry.³⁴ Records from the time failed to differentiate those tanks destroyed by infantry antitank weapons, such as the bazooka, from those tanks destroyed by close infantry assault. Even lumped together, the two types of attacks failed to make up any significant number of American tanks destroyed. From the beginning of

the war through January 1951 only 13 percent of US tanks were knocked out by infantry attack.³⁵ During the second half of 1951 only 8 percent of tanks lost were destroyed by infantry attack.³⁶

Artillery threatened armored vehicles in Korea just as it did in World War II. The North Koreans and Chinese used artillery in combination with their infantry assaults on US forces posted in defensive positions on the steep hills of Korea. When US units began employing armored vehicles in static positions in support of infantry formations the vehicle positions often were subjected to significant artillery barrages before enemy attacks. During the first seven months of the war only 4.8 percent of American armored vehicle losses were due to artillery and mortar fire.³⁷ The percentage of loss to indirect fire remained at a constant low rate throughout the war. Although few American vehicles were destroyed by artillery, the threat led to a significant number of modifications by armored vehicle crews.

Mine Warfare

By far the single greatest threat to American vehicle crews, both armored and unarmored, during the Korean War was the mine. Both sides made relatively limited use of mines during the early stages of the war. As the North Koreans retreated northward up the peninsula during the fall of 1950 they increasingly used mines to delay and disrupt United Nations forces as they attacked north. Before they evacuated Seoul the North Koreans mined virtually every intersection.³⁸ Use of mines increased as the two belligerents battled back and forth and eventually reached a stalemate, on the Korean Peninsula. North Korean and Chinese forces employed a wide array of models and types of mines from several countries of origin. From the Soviet Union they acquired TMB-D

wooden antitank, POMZ-2 antipersonnel, TM-41, PMD-6, TM-38, YaM and PMD-7 mines. American forces encountered World War II era Japanese Type 93 and Type 99 mines and Chinese Number 4 and Number 8 mines. The Chinese and North Koreans also proved adept at employing captured American M6 antitank, M7 antitank, M3 antipersonnel and M2A3 antipersonnel mines as well.³⁹ In one incident near Pusan in September 1950 North Korean infantry infiltrated the 1st Cavalry Division's lines and placed forty-two US M6 antitank mines along a road in a supposedly secure area under the cover of darkness. The next morning two M4A3E8 Shermans were disabled as they attempted to move along the route.⁴⁰ The American IX Corps located and destroyed 750 mines in October 1951.⁴¹ During the same month the I Corps stated that mines were the "most effective" antitank weapon they encountered.⁴² During the period from 1 July 1950 to 21 January 1951, the enemy destroyed fifty-six M26-46 medium tanks and seventy-six M4A3E8 medium tanks. Of those total numbers of tanks destroyed twenty-seven of the M26-46 and thirty-three of the M4A3E8 tanks were destroyed by mines.⁴³

Protection Modifications

During the Korean War field expedient modifications to armored vehicles fell into two general categories. The first category was modifications made that attempted to increase a vehicle's capacity to resist enemy fire. This primary protection usually sought to increase the thickness of American vehicles' armor. Crews added barrier material to correct perceived deficiencies in their vehicles' protection. The second category of modification encompassed modifications that improved a vehicle's protection by means other than simply adding more material to the existing armor. Some examples of these

changes included paint and camouflage and addition of devices to communicate with infantry on the ground.

Sandbagging of armored vehicles, the most common field expedient modification conducted by armor crews in World War II, proved to be a less prevalent means of augmenting primary protection during the Korean War. One of the reasons that US crews did not sandbag their vehicles as much as they did during World War II was the fact that the threat from North Korean and Chinese antitank guns and infantry antiarmor weapons was less sophisticated and less effective than the German threat had been half a decade earlier. The organic armor on M26-46 Pershing tanks generally provided sufficient protection from enemy 76-millimeter and 85-millimeter fire from both tanks and antitank guns.⁴⁴ The infrequency of tank versus tank engagements, along with the improved effectiveness of US armored vehicle protection, significantly reduced the motivation for crews to add sandbags to their vehicles. Following the U.N. counteroffensive in late 1950 armored vehicle crews rarely saw enemy tanks.

The greatest impetus to sandbag armored vehicles evolved along with the static warfare that characterized the final two years of the war. Armored vehicle crews increasingly came to be used in immobile hilltop positions in an infantry support role as well as in augmenting traditional artillery by using their main guns in an indirect fire role. Tanks routinely used their main guns to support infantry units in destroying enemy bunkers and field fortifications. Tanks also served as defensive strongpoints to provide main gun and machine gun support to infantry units in the defense against North Korean and Chinese infantry attacks. These infantry support and indirect fire roles forced many crews to create sophisticated emplacements with sandbags and earth filled wooden

ammunition containers to fortify their positions. Once the crew determined the location of the vehicle emplacement, they created walls and berms of sandbags to reduce the effectiveness of enemy antitank fire. Often, these positions included sandbags stacked several layers deep on a tank's rear deck to reduce the effectiveness of mortar and artillery fire on the fixed positions.⁴⁵ If crews needed to move their vehicles for maintenance or resupply they would remove the sandbags from the rear decks of their vehicles and leave them in the position. As soon as the vehicle returned the crew would then replace the layer of protection on their vehicle's rear deck.

Marine Corps crews manning LVT(A)-5 amphibian tractors found a need to make significant use of sandbags. By the summer of 1952 no amphibious activity was needed so Marine units began to employ lightly armored LVT(A)-5s in an infantry support role. The machine guns and 75-millimeter main guns provided significant firepower for Marine infantry battalions. Because of the light armor of the vehicles, the 1st Armored Amphibian Tractor Battalion added multiple layers of sandbags to the tops of their vehicles' decks and turrets to add protection against enemy indirect fire. The sandbagging proved effective in reducing the vulnerability of the LVT(A)-5 amphibians in the infantry support role.⁴⁶

A second means of improving the primary protection of armored vehicles directly resulted from the most prevalent and dangerous threat to US armored crews in Korea. All American tanks from the Korean War period incorporated an escape hatch built into the belly of the vehicle. This hatch constituted a weak point in the already lightly armored undercarriage of American tanks. Crews in the 104th Tank Battalion reported that the escape hatches in Sherman and Pershing medium tanks tended to blow inward into the

crew compartment when the tanks struck mines.⁴⁷ In response, crews welded used tank drive sprockets or other steel supports to reinforce the troop escape hatches. Studies conducted in Korea determined that crew members were usually seriously wounded or killed in tanks that struck a mine with unmodified escape hatches. Crews were usually badly shaken or slightly injured, but not killed, in tanks that struck a mine after having field improvements made to their escape hatches.⁴⁸

The final example of primary protection modifications that was used in Korea was a response to the threat of enemy shaped charge weapons against tanks. Although the enemy did not possess great numbers of shaped charge weapons they did employ enough of them to force Marine tank crews to fashion screens from wire mesh and chain link fencing.⁴⁹ The weapons the Marines were particularly worried about were American 2.36 inch and 3.5 inch bazooka rocket launchers captured by the North Koreans and the Chinese.⁵⁰ The premise behind the screens was that the mesh provided enough resistance to detonate the shaped charge weapon before it came into contact with the actual armored skin of the vehicle. The resulting stand off distance dissipated the explosive force of the weapon and reduced the danger to the crew.

Other Modifications

The second category of modifications encompassed changes that improved a vehicle's protection by means other than simply adding more material to the existing armor. Often the changes involved preventing or mitigating the effects of close infantry attacks on armored vehicles. Along those same lines, improving cooperation with friendly infantry forces often led to modifications conducted by armored vehicle crews.

An area of secondary protection that became more and more common as the war progressed was the use of paint schemes and camouflage on armored vehicles. A survey team sent to Korea in July and August 1950 found that: "Troops in Korea employed no camouflage equipment or defective devices."⁵¹ As the war progressed then became more stable, however, crews began to use paint to achieve two distinct effects. The first, more traditional, technique involved using paint to camouflage armored vehicles to make them more difficult for the enemy to acquire and engage. Most camouflage patterns reflected the 72nd Tank Battalion's method of using layers of earthen brown paint over the standard olive drab paint to better match the Korean terrain and vegetation common during the dry summer months.⁵² Units likewise applied whitewash or white paint during the winter months to help vehicles blend into the winter landscape and increase protection by degrading the enemy's ability to observe US armored vehicles.

The second effect that crews attempted to create with paint in Korea revolved around a commonly held American stereotype that North Korean and Chinese troops feared tigers and dragons. Crews believed that they could capitalize on this superstition by using bright paint to decorate their tanks in gaudy caricatures of big cats and dragons. No results were available on whether or not the paint modifications had any effect on the enemy. While the painted tanks didn't provide any improvement in secondary protection, the wild paint schemes did increase American crew morale and the period when decorated tanks were in vogue did provide some of the most colorful, unique and inventive paint schemes in US armored history.⁵³

An area of secondary protection that again, like World War II, proved problematic for armored crews was communication between armored vehicle crews and infantry

operating on the ground. A report published in April 1951 recorded that communications between tanks and infantry “exhibit no evidence of improvement over the quality of communications during World War II.”⁵⁴ Even though the M26-46 Pershing tanks included an infantry phone mounted on the rear deck of the tank, soldiers reported not using the device because it was often broken or because the placement of the device required infantrymen to stand up in order to use it. The Sherman medium tanks employed in Korea still did not have infantry phones. Armored crewmen and infantrymen relearned the lessons of World War II and installed field expedient phones on their Sherman tanks or modified the poorly placed phones on their Pershing tanks.⁵⁵

Although American armored crewmen fought the Korean War with the same equipment that they fought World War II with they modified their vehicles in the field much less than their counterparts did during the earlier war. Several factors caused the difference in numbers and type of modifications. The difference in level of threat faced by US crewmen between the two wars accounts for the difference. The North Koreans and Chinese possessed relatively few tanks at the beginning of the war and the number of those tanks dropped steadily during the course of the war. Effective antitank guns were another North Korean and Chinese weakness. America's enemies in Korea also lacked any significant numbers of hand-held antiarmor devices, such as the German *panzerfaust* or *panzerschreck*. Mines did pose an enormous threat to armored vehicles but crews could devise few modifications to deal with the threat. Except for modifying the escape hatches of tanks, which did improve the primary protection of American vehicles, crews could not find ways to successfully counter the enemy mine threat in Korea. Artillery and mortar fire provided the only other real opportunity for crews to improve the primary

protection of their mounts. Sandbagging gave improved levels of protection to all models of tanks and greatly improved the protective qualities of the Marine Corps' armed amphibian tractors.

The relative brevity of the conflict and the isolated nature of the conflict helped in keeping down the numbers and variations of modifications that US crewmen made to their armored vehicles. The Korean War lasted only three years. This short time span limited the crews' ability to experiment and try new modifications. Additionally, the time span of active operations lasted only about a year. After the war became static crews faced an unchanging operational environment. The mine threat increased with every month of the war and the artillery threat remained constant but little changed during the unending stalemate of the final years of the war.

The geographic isolation of the war also limited expedient modifications. World War II, of course, was a global war that was fought against several enemies on vastly divergent and ever changing battlefields. In Korea, armored crews adapted their vehicles for the environment and enemy to some extent but the lack of changing environments and changing opponents stifled development of field expedient modifications.

¹George F. Hofmann, "Tanks and the Korean War: A Case Study in Unpreparedness," *Armor* 109, no. 5 (2002): 9.

²Steven J. Zaloga, *M26/46 Pershing Tank, 1943-1953* (Oxford, United Kingdom: Osprey Publishing, 2000), 41.

³*Ibid.*, 40.

⁴"Report of Army Field Forces Observer Team Number 6" (Fort Monroe, Virginia: Office, Chief of Army Field Forces, 7 April 1952): Appendix G, p. 5.

⁵William P. Withers, "Report From Korea," *Armor* 60, no. 2 (1951): 23.

⁶Harry H. Shields Jr., James L. Andrews, Carroll M. Cook Jr., Loren E. Davis, Kenneth W. Fisher, "Employment of Armor in Korea: The Second Year" (Fort Knox, Kentucky: The Armored School, 1953): 111.

⁷Zaloga, *M26/46 Pershing Tank*, 8.

⁸*Ibid.*, 18, 22.

⁹"History and Role of Armor, US Army Armor Center Pamphlet 360-3" (Fort Knox, Kentucky: US Army Armor Center and Fort Knox, 1 May 1994), 29.

¹⁰Zaloga, *M26/46 Pershing Tank*, 28.

¹¹*Ibid.*, 35.

¹²*Ibid.*

¹³Robert E. Miller, William B. Fowlkes, Peter B. Bennett, Harold H. Lee, and Hugh Cort Jr., "Separate Tank Battalion Versus the Tank Regiment" (Fort Knox, Kentucky: The Armored School, 1951-52): 30.

¹⁴Milton R. Thompson, Harry B. Hardy, Kibbey M. Horne, Kenneth W. Koch, and Jack F. Matteson, "Employment of Armor in Korea: The First Year," vol. I (Fort Knox, Kentucky: The Armored School, 1952): 58, 63.

¹⁵Philip L. Bolte, "Post-World War II and Korea: Paying for Unpreparedness," in George F. Hofmann and Donn A. Starry, eds., *Camp Colt to Desert Storm, The History of US Armored Forces* (Lexington, Kentucky: University Press of Kentucky, 1999), 225.

¹⁶Arthur W. Connor Jr., "The Armor Debacle in Korea, 1950: Implications for Today," *Parameters* 22, no. 2 (1992): 68.

¹⁷Thompson et al., "Employment of Armor in Korea: The First Year," vol. I, 47.

¹⁸*Ibid.*, 49.

¹⁹"Report of First OCAFF Observer Team to the Far East Command" (Fort Monroe, Virginia: Headquarters, Chief of Army Field Forces, 16 August 1950): 7.

²⁰Jim Mesko, *Amtracs in Action, Part I* (Carrollton, Texas: Squadron/Signal Publications, 1993), 31.

²¹*Ibid.*, 6, 13, 29.

²²Bolte, "Post-World War II and Korea," 224.

²³H. W. MacDonald, E. D. Strong, W. Van Royen, I. J. Breen, C. Billingslea, R. W. Brittain, and E. A. Johnson, "The Employment of Armor In Korea," vols. I & II (Operations Research Office, Far East Command, 8 April 1951): 27.

²⁴Ibid.

²⁵AFF Report Number 6, Appendix G, p. 7.

²⁶Bolte, "Post-World War II and Korea," 224.

²⁷Miller et al., "Separate Tank Battalion Versus the Tank Regiment," 30.

²⁸Shields et al., "Employment of Armor in Korea: The Second Year," 54, 62.

²⁹Ibid., 98.

³⁰Ibid., 101.

³¹E. D. Strong and W. A. Taylor, "Mechanical Reliability and Combat Zone Fuel Logistics of U.N. Tank Units" (Operations Research Office, Far East Command, 28 February 1951): 4-5.

³²AFF Report Number 6, Appendix G, p. 7.

³³Shields et al., "Employment of Armor in Korea: The Second Year," 101.

³⁴MacDonald et al., "The Employment of Armor In Korea, Volume I & II," 13.

³⁵Ibid., 27.

³⁶AFF Report Number 6, Appendix G, p. 7.

³⁷MacDonald et al., "The Employment of Armor In Korea, Volume I & II," 27.

³⁸"Landmine and Countermine Warfare, Korea, 1950-1954," Prepared for Department of the Army, Chief of Engineers (Washington, D.C., Engineer Agency for Resources Inventories, 1972), vii.

³⁹Ibid., viii, x.

⁴⁰Ibid., 11.

⁴¹Shields et al., "Employment of Armor in Korea: The Second Year," 54.

⁴²Ibid., 27.

⁴³Strong et al., "Mechanical Reliability", 4-5.

⁴⁴Thompson et al., “Employment of Armor in Korea: The First Year, Volume I,” 58.

⁴⁵Simon Dunstan, *Armour of the Korean War, 1950-53* (London: Osprey Publishing, Limited, 1982), 150.

⁴⁶*Ibid.*, 33.

⁴⁷*Ibid.*, 29.

⁴⁸“Landmine and Countermine Warfare, Korea, 1950-1954, Appendixes III” Prepared for Department of the Army, Chief of Engineers (Washington, D.C., Engineer Agency for Resources Inventories, 1972): v-2.

⁴⁹Oscar E. Gilbert, *Marine Corps Tank Battles in Korea* (Havertown, Pennsylvania: Casemate, 2003), 237.

⁵⁰Zaloga, *M26/46 Pershing Tank*, 47.

⁵¹“First OCAFF Observer Team to the Far East Command,” 6.

⁵²Dunstan, *Armour of the Korean War*, 36.

⁵³Jim Mesko, *Armor in Korea, A Pictorial History* (Carrollton, Texas: Squadron/Signal Publications, 1984), 39-46.

⁵⁴MacDonald et al., “The Employment of Armor In Korea, Volume I & II,” 41.

⁵⁵*Ibid.*, 3, 41.

CHAPTER 4

THE VIETNAM WAR

Vietnam is no place for either tank or mechanized infantry units.¹

General W. C. Westmoreland, “US Army Armor In Limited War”

General William C. Westmoreland uttered the words from the quotation above during the initial stages of the American military buildup in Vietnam in 1965. General Westmoreland’s skepticism concerning the usefulness of armored vehicles in Vietnam continued until the first Marine and Army armored units demonstrated their effectiveness in combat operations. Eventually, armored units became integral to operations in Vietnam. Like World War II, the combination of long US involvement in Vietnam and the particular methods employed by the Viet Cong and North Vietnamese Army provided significant opportunities for American crewmen to create expedient modifications for their armored vehicles.

US Equipment

As early as spring 1965 US made armored vehicles manned by American crews began to appear on the battlefields of Vietnam. Tanks and armored personnel carriers served their crews across the breadth of Vietnam until the last major units withdrew in 1972. US Army and US Marine Corps crews fought in M48 Pattons as the dominant tank of the war. Additionally, Army troops fielded, tested and fought the new M551 Sheridan Armored Airborne Assault Reconnaissance Vehicle from 1969 until the end of the war. Armored personnel carriers in combat service with the US Army made their debut in Vietnam in the form of the M113 Armored Personnel Carrier. Marine crews utilized an

evolutionary variant of their long line of armored amphibious vehicles with the LVTP5 Amtrac for much of the war.

The US Army unveiled its first completely new tank since World War II, the M48 Patton medium tank, in July 1952.² By the time production ceased nearly 9,500 M48s, of all variants, had rolled off American production lines.³ The Patton underwent several redesigns and modifications during the years between its fielding and first employment in Vietnam. The version that saw, by vast majority, the most combat in Vietnam was the M48A3. The fifty-three ton tank carried a crew of four.⁴ Armament consisted of a 90-millimeter main gun capable of firing high explosive, high explosive antitank, white phosphorus, canister and beehive ammunition.⁵ The M48A3 also included a 7.62-millimeter machine gun mounted coaxially with the main gun and a .50-caliber machine gun in the tank commander's cupola. The M48's engine could produce thirty-miles-per-hour maximum speed and a cruising range of about 300 miles. Nearly seven inches of armor protected the front of the turret while the sides and rear of the turret were comprised of three and two inches of armor, respectively. The front of the hull was made up of 4.33 inches of armor while the sides of the hull carried three inches of armor. Thickness of the hull floor varied between 1 inch and 1.5 inches of armor.⁶

Initial design work on the second major US turreted vehicle of the Vietnam War began in 1959. The vehicle, originally designed to provide armored support for airborne forces, suffered a troubled development process between 1959 and 1968, when it was finally approved for deployment for combat in Vietnam.⁷ Early in 1969 two units in Vietnam, the 11th Armored Cavalry Regiment and 3rd Squadron, 4th US Cavalry, received the first sixty Sheridans for training, testing and evaluation under combat

conditions. Despite several design flaws such as problems with secondary ammunition explosions and electrical problems, the decision was made to deploy more Sheridans to Vietnam.⁸ Eventually, nearly 500 M551 Sheridans saw combat in Vietnam.⁹

The aluminum armored Sheridan weighed only sixteen tons. This light weight gave it a top speed of forty-three miles per hour, a 373-mile cruising range and excellent mobility over a wide variety of terrain. A 152-millimeter main gun fired high explosive antitank and canister ammunition as well as an antitank missile that was not used in Vietnam due to the lack of Viet Cong or North Vietnamese Army armored threat. For secondary armament the Sheridan mounted a 7.62-millimeter machine gun in a coaxial mount alongside the main gun and an M2 .50-caliber machine gun on a pedestal mount at the tank commander's position.¹⁰ The Sheridan received official modifications immediately before and during its deployment to Vietnam. The most significant improvement involved addition of more belly armor for the tank as well as a ballistic gun shield for the commander's machine gun.¹¹

By far, the armored vehicle employed the most widely in Vietnam was the M113 Armored Personnel Carrier. More than 40,000 M113s saw service in Vietnam in about sixty different configurations.¹² The basic M113 vehicle amounted to little more than a fully tracked aluminum armored box that weighed 11.3 tons and could carry a wide array of personnel and equipment.¹³ Armor thickness varied, but in general about one to 1.5 inches of aluminum armor protected the front and sides of the vehicle. Floor protection, a characteristic that proved vital in Vietnam, amounted to 1.13 inches in the hull floor itself plus .25 inches of protection from the aluminum sub-floor of the vehicle.¹⁴ The original M113 employed in Vietnam incorporated a gasoline driven engine. Starting in 1964, the

US Army began replacing the gasoline fueled M113s with diesel fueled M113A1s.¹⁵ All units in Vietnam traded in their M113s for M113A1s by July 1968.¹⁶ The basic M113 required a crew to two soldiers; a driver and a vehicle commander. The vehicle incorporated a crew served weapon mount at the vehicle commander's position. Most commonly, a M2 .50-caliber machine gun provide firepower for the M113.

Several types of units used the M113 in Vietnam. Mechanized infantry battalions provided the greatest user of M113 Armored Personnel Carriers. Within mechanized infantry units, the M113 provided the primary transportation and fighting vehicle for infantry squads, platoons and companies. Additionally, mechanized infantry organizations used M113s in a myriad of combat and combat service support roles. The second type of units that employed the M113 were the armored units deployed to Vietnam. Tank battalions and companies used M113s to augment their M48 Patton equipped fighting formations with combat support and combat service support functions. Ground cavalry units, both the divisional cavalry squadrons and regimental cavalry squadrons, utilized M113s in much the same way as mechanized infantry outfits. In cavalry organizations, the M113 served as both a fighting vehicle as well as a combat support and combat service support vehicle.¹⁷

Prior to deployment of M113s to Vietnam, the Army embarked on a program of systematic modifications to M113s. The most significant change originated in 1966 as the 11th Armored Cavalry Regiment prepared for deployment to Vietnam. Based on experiences with M113s of the Army of the Republic of Vietnam, the 1st Squadron, 11th Armored Cavalry Regiment, added a protective gun shield to the vehicle commander's station as well as two 7.62-millimeter M60 machine guns, with gun shields, mounted in

flexible mounts in the crew compartment. The 11th Armored Cavalry Regiment dubbed the creation the “Armored Cavalry Assault Vehicle,” or “ACAV.”¹⁸ The Army codified the modification by designating equipment as an A model kit, that was widely distributed to all users of the M113 throughout the Vietnam War.¹⁹

From the very beginning of the US Marine Corps’ participation in the Vietnam War in 1965, the Marines used M48 tanks to support their infantry operations and amphibious armored personnel carriers to conduct amphibious operations as well as transport infantry on land. The amphibian vehicle of choice for the Marines during the Vietnam War was the “Landing Vehicle, Tracked, Personnel, 5;” or LVTP5. The thirty-two-ton vehicle could carry a crew of three and a maximum of thirty-four troops, although a troop load of twenty-five was considered optimal. The lightly skinned vehicle protected its passengers with about .6 inches armor and one .30-caliber machine gun. The LVTP5 could reach a speed of thirty-miles-per-hour on land and 6.8 miles per hour in the water.²⁰

Communist Equipment

This collection of armored vehicles faced an enemy that lacked the traditional antiarmor weapons that US crewmen faced during World War II and the Korean War. US forces encountered only a handful of enemy armored vehicles during the course of the entire Vietnam War and conducted only one engagement where US armored vehicles fought against enemy armored vehicles. Additionally, the Viet Cong and North Vietnamese Army used traditional antitank guns very little. The primary methods employed by the Americans’ enemy in Vietnam were the rocket propelled grenade and the mine.

Rocket propelled grenades provided the enemy with a cheap, easy to transport and simple to employ antiarmor killing system. The most common models that the Viet Cong and North Vietnamese Army employed were the Soviet designed RPG-2 and RPG-7 rocket propelled grenades.²¹ The rocket propelled grenade launchers became so ubiquitous on Vietnamese battlefields that General Creighton W. Abrams Jr., then the commander of all US force in Vietnam, commented that “the B-41 RPG-7 is the best hand-held antitank gun in the world.”²² Most often, the enemy used rocket propelled grenade launchers in concert with mortars, machine guns, small arms, and command detonated mines in ambushes of American mounted units. Some enemy units, however, devised methods to remotely command-detonate rocket propelled grenades from bamboo poles placed along roadsides at a forty-five degree angle towards the traveled surface. The Viet Cong or North Vietnamese unit conducting the ambush would wait until nightfall, then set off the device via wire from a remote location as an American vehicle passed by.²³ Although rocket propelled grenades did pose some threat to Army and Marine M48A3 tanks, the rocket propelled grenade posed a more significant threat to the lightly armored M113 and LVTP5 armored troop carriers. Crews reported that Patton tanks often took several strikes from RPG-2 and RPG-7 projectiles yet still continued to fight.²⁴ In one notable example during the 1968 Tet Offensive, a M48A3 remained operational after nineteen separate rocket propelled grenade struck it in action around Bien Hoa Air Base.²⁵ The enemy proved to be more effective in their use of rocket propelled grenades launchers against American armored personnel carriers. In one instance, a crewman who served in the 2nd Battalion, 47th Infantry (Mechanized), in 1969-1970 observed a rocket propelled grenade penetrate completely through both sides

of a M113A1.²⁶ Once the M551 Sheridans were introduced in 1969 they, like the M113s, proved vulnerable to rocket propelled grenade fire. During the first three months of service the original sixty Sheridans suffered twelve rocket propelled grenade strikes. Five of the twelve rocket strikes resulted in total loss of the vehicle. Lieutenant Colonel Frank E. Varljen, who commanded the 1st Squadron, 11th Armored Cavalry Regiment, in 1970-1971, described rocket propelled grenade attacks and mines strikes as often “devastating” to the unit's Sheridans.²⁷ Despite the vulnerability of the M551s, the assessment team that accompanied the initial deployment of Sheridans determined that the new tanks provided better protection from both rocket propelled grenades and mines than the M113 vehicles they replaced.²⁸

The enemy’s use of mines posed, by far, the greatest single threat to American armored vehicles during the Vietnam War. Major General George S. Patton, who commanded the 11th Armored Cavalry Regiment in Vietnam as a colonel in Vietnam, said of mines:

Mines! Be on your guard for the enemy’s mine warfare capability. Of all the weapons used against the armored units with which I had the good fortune to be associated, this small box of explosives, randomly but effectively placed, gave me the greatest cause for concern. Viet Cong/NVA mine employment was extremely effective, and caused at least fifty percent of my AFV [armored fighting vehicle] losses.²⁹

The most common manufactured mines encountered by US mounted forces were the Soviet TMB-2 antitank, TM-46 antitank, PMN antipersonnel; East German PM60 antitank and Chinese Number 4 dual-purpose mines.³⁰ In addition to mines created in Soviet, Chinese and East German factories, the enemy manufactured a bewildering variety of expedient explosive devices. Viet Cong and North Vietnamese troops became highly skilled at creating pressure and command detonated mines from captured

American munitions, dud artillery rounds, stolen explosives and aerial bombs. The 1st Battalion, 69th Armor, reported encountering mines created from 105-millimeter artillery rounds, and even larger American munitions, in Binh Dinh Province in 1968.³¹

Mines usually damaged, but did not catastrophically destroy, M48A3 Patton tanks that experienced a mine strike. Mines most often caused damage to tank tracks, road wheels and suspension components but rarely penetrated the vehicle's hull.³² One officer who served with the 1st Battalion, 69th Armor, observed that in 1967 a M48A3 from the battalion's A Company survived a detonation of a 500 pound aerial bomb.³³ Often, crewmen were injured but rarely killed by mines. Of the sixty original Sheridans issued to the 11th Armored Cavalry Regiment and 3rd Squadron, 4th US Cavalry, in 1969, ten vehicles struck mines during the first ninety days of operations. Only one of the ten mine strikes resulted in a catastrophic loss to the vehicle.³⁴

The M113s that hit mines were often catastrophically destroyed by mine strikes by the heavier antitank mines and expedient mines created from munitions larger than 105-millimeter artillery projectiles. Mines caused 70 percent of American tank and armored personnel carrier losses and 4,300 total US casualties in 1967.³⁵ In June 1966, the 1st Battalion, 5th Infantry (Mechanized) from the 25th Infantry Division lost fourteen M113s destroyed to mine strike in eight days.³⁶ During the period from January to March 1969, the 1st Battalion, 69th Armor, found 115 mines on Highway 19 near Pleiku. Twenty-seven of those mines were detected and destroyed while eighty-eight exploded and caused damage to the battalion's Patton tanks. Seventy-three percent of all tank losses in Vietnam from November 1968 to May 1969, and 77 percent of all M113 losses, resulted from mine strikes.³⁷ American forces reported in a 1966 lessons learned

document that the enemy could interdict any route in the area of operations with mines and recommended that US forces use off road travel as much as possible due to the wide spread enemy use of mines on established routes.³⁸

Protection Modifications

To counter the enemy's widespread use of mine warfare and attacks with rocket propelled grenades, armored vehicle crewmen devised a wide array of field expedient modifications to improve the protection of their vehicles. Like the armor expedients that Soldiers and Marines created during World War II and Korea, the expedients that appeared during the Vietnam war fell into two categories; primary and secondary expedients. The primary expedient modifications sought to improve the basic protective quality of the vehicles' armor. Some of the methods in this category included the venerable sandbag and added metal armor, most often in the form of steel airfield runway matting. The basic idea was to put more material between the enemy's munitions and the vulnerable interior of the vehicle.

Secondary armor modifications included a wide array of changes to vehicle armament and a widespread use of chain link fencing to create rocket propelled grenade screens. The armament modifications sought to indirectly improve the level of vehicle protection by increasing the vehicle's firepower. Increased firepower allowed crews to destroy the enemy before they could engage the crews with rocket propelled grenades or command detonated mines. The chain link fence's desired effect was to force detonation of the rocket propelled grenade's warhead before it reached the armored skin of the combat vehicle.

Like their predecessors in previous wars, armored vehicle crewmen in Vietnam relied on the common sandbag as the predominant material to increase the primary protection of their mounts. Again like the men who fought before them, crews found a myriad of different ways to use sandbags. Most of the sandbagging took place in the interiors of tracked vehicles to improve the protection that thin belly armor afforded against mine strikes. According to Major General A. L. West, the lead author of a massive study of armored operations in Vietnam that was conducted in 1967, most M113 crews lined the floors of their armored personnel carriers with at least one, most often two, layers of sandbags to reduce mine damage.³⁹ A platoon leader in a divisional cavalry squadron ordered his men to sandbag every vehicle, including their Patton tanks, after he saw a M113 hit a large mine and get completely flipped over by the detonation.⁴⁰ For M113s specifically, and most armored vehicles in general, the floor under the vehicle driver's compartment usually received particular attention with sandbags. The driver of every combat vehicle of the Vietnam War sat closest to the thinly armored belly of a tank or armored personnel carrier. His position was also the farthest forward of any crewman in an armored vehicle. He would, usually, bear the brunt of any mine strike the vehicle encountered.

The practice of sandbagging vehicles was not limited to M113 vehicles. The 1st Marine Division issued an order on 14 February 1969 directing that all vehicle crewmen place a layer of sandbags on the floor of their vehicles, including tracked vehicles, with a thick rubber mat laid over the sandbags. The intent of the mat was to reduce the spalling effect of the mine detonation. Spalling was the effect created when an explosive pushed

metal and sand, whatever stood between the explosive and the vehicle interior, into the space occupied by a crew.⁴¹

Although exterior sandbagging was much less common in Vietnam than in World War II or Korea, crews did not limit their sandbagging efforts to vehicle interiors. M48A3 crews sometimes covered their turrets with sandbags as a defense against shaped charge weapons such as RPG-2s and RPG-7s.⁴² Crews from the 1st Tank Battalion, 1st Marine Division, used wire cables to hold sandbags in place around the driver's hatch of their Patton tanks.⁴³ Troopers from the 11th Armored Cavalry Regiment build walls out of sand filled ammunition crates on top of their M577 command post carriers, a variant of the basic M113, to protect riders that sat on top of the vehicle rather than inside.⁴⁴ Marine infantry disliked riding inside the LVTP5 amphibian because of its thin belly armor and the fact that the gasoline driven vehicle's fuel tank was located in the crew compartment of the vehicle. The Marines, therefore, built sandbag walls on top of the vehicle to reduce the threat to Marines riding on top of the vehicle.⁴⁵

Whether or not any real improvement in overall protection was achieved by these field expedient sandbag improvements was hard to gauge. Studies conducted in Vietnam during the war demonstrated that, at least for the M113 series vehicles in country, field expedient protection was, at best, marginally successful. Tests with small charges of dynamite, ten to fifteen pounds, resulted in no rupture of the M113 hull.⁴⁶ Testers then detonated larger charges, up to thirty pounds of dynamite, against both unmodified and modified M113 hulls. The larger tests corresponded in size to the weight of mines then being employed by the Viet Cong and North Vietnamese Army.⁴⁷ In all tests with the larger charges, the M113 hulls were ruptured whether or not any field modifications had

been applied to the M113 or not. The study summarized the results by stating that “the supplemental [field expedient] armor systems manufactured from in-country materials do not improve the capability of the M113 APC to withstand mines.”⁴⁸ Additionally, the larger charges produced an effect where the whole vehicle, whether it was ruptured or not, accelerated vertically with such a rapid rate that crewmen inside would be injured regardless of expedient hull protection. Crewmen and passengers would be injured by the movement of the whole vehicle whether they sandbagged their vehicle or not.⁴⁹

Despite the experimental evidence, however, crews continued to make the effort to sandbag their armored vehicles. They continued the practice even though it caused problems with maintenance and vehicle mechanical reliability. One unit, the 1st Squadron, 1st US Cavalry, heavily sandbagged their vehicles soon after they arrived in Vietnam. During the first forty-five days of operations, fourteen M113 transmissions failed as a result of the added weight of two layers of sandbags that the unit used.⁵⁰ An armor officer who served in Vietnam summarized that the “protection afforded by this innovation [sandbagging] was more psychological than physical, especially against mines. Some protection was achieved from small arms, however.”⁵¹ A possible reason for crews continuing the practice of sandbagging is that it gave them some sense that there was something they could do to positively affect their chances of survival against mines.

Marine and Army crewmen alike found other ways of adding materials they hoped would improve the primary protection of their armored vehicles. In the 3rd Squadron, 4th US Cavalry, crews hung sections of perforated steel runway planking on the sides of their Patton tanks to cover the vulnerable running gear.⁵² The intent was to

defeat the enemy's shaped charge weapons, the rocket propelled grenades. The theory worked on the premise that if something forced the shaped charge warhead to detonate prior to impact with the actual vehicle armor, then much of the resulting molten jet created by the shaped charge would dissipate prior to penetrating a vehicle's armor. The perforated planking, which was often used in runway construction in Vietnam, was supposed to provide enough resistance to force early detonation of the warhead. Crewmen of M113s, LVTP5s and Sheridans, as well as Patton tanks, used many of the same materials that World War II crewmen employed to improve the protection of their vehicles. Spare track sections, ammunition boxes, ration boxes and the new perforated runway matting found its way onto the exteriors of armored vehicles across the length and breadth of Vietnam. Anything that could possibly stop a rocket propelled grenade round before it contacted the vehicle skin was used.⁵³

A modification technique that was widely used in Vietnam bridged the gap between the classification as a primary protection modification and a secondary protection modification. Ordinary chain link fence served as a primary technique because its goal was to detonate rocket propelled grenade shaped charge warheads before they impacted the main armor of a tank or armored personnel carrier. Most units, however, did not apply the chain link fence, which came to be known as rocket propelled grenade screens, directly to their vehicles. When vehicles were stationary, such as in a night defensive position, crews set up a simple chain link fence some distance in front of the vehicle. For this reason, the fences could be classified as a secondary protection modification.

Whatever category the field expedient fences fell into, the chain link screens proved to be a simple, cheap and extremely effective method of reducing the effectiveness of Viet Cong and North Vietnamese Army rocket propelled grenades against American combat vehicles. In the Ben Cui Rubber Plantation in September 1968 the North Vietnamese Army launched four assaults in nine days against the 1st Battalion, 5th Infantry (Mechanized), with small arms, machine guns, mortar and rocket propelled grenades. The only real damage during those nine days was caused by rocket propelled grenades. As a response, the battalion adopted a standard kit of a fifty by eight foot section of chain link fence and engineer pickets for each armored vehicle. Crews erected the screen about eight feet in front of each vehicle. Following the September 1968 engagements, battalion vehicles were not considered combat ready unless they had the required rocket propelled grenade screen. Once the battalion adopted the chain link fence technique, crews would often find rocket propelled grenade projectiles hanging in their fences following a fight. The battalion's losses to enemy rocket propelled grenades dropped once crews started using the screens.⁵⁴

Mechanized infantry units, with their large numbers of M113s, were not the only types of organizations to adopt the rocket propelled grenade screen. Cavalry and armored units including the 11th Armored Cavalry Regiment, 2nd Squadron, 1st US Cavalry, 3rd Squadron, 4th US Cavalry, and many others used the simple technique. The M113s were not the only vehicles protected by the fences, either. Crews from M551 Sheridans and M48A3 Pattons used the device.⁵⁵ Finally, the fence was not just for vehicles. Many units protected bunkers and individual fighting positions with the screens.⁵⁶

Other Modifications

Crews' modifications to the weapons of their armored vehicles provided a type of field expedient modification that lay squarely in the realm of secondary protection enhancements. The addition of more weapons or changes to the organic weapons of a vehicle did not improve the protective capacity of the vehicle itself, but the increased killing power improved survivability because it increase the crews' ability to protect themselves from North Vietnamese and Viet Cong attacks. Most specific examples of changes to a vehicle's weapons suite involved adding more weapons than the vehicle was originally designed to carry or changing how the weapon was mounted or operated to improve performance.

The basic design of the tank commander's .50-caliber machine gun on the M48A3 tank produced the most fertile ground for change. According to Sergeant Ralph Zumbro, a tank gunner and tank commander for A Company, 1st Battalion, 69th Armor, during 1967-1968, the "cupola gun on the M48A3 is the worst combat mount ever devised."⁵⁷ The problem with the .50-caliber mounting system in the M1 cupola on the M48A3 was that the machine gun lay on its side and presented great difficulty accessing, loading and operating the gun.⁵⁸ As a result, many Patton tank crews removed the .50-caliber machine gun from its mount and moved it to an M3 tripod mount welded to the top of the turret directly in front of the tank commander's hatch.⁵⁹

Another design flaw that prompted field expedient modification involved the coaxial machine gun on the M551 Sheridan. The standard ammunition can did not hold enough ammunition and often caused problems feeding ammunition to the machine gun. Within forty-five days of arrival in Vietnam, the Sheridan crews modified their coaxial

machine guns with ammunition cans from M48A3 tanks or 20-millimeter helicopter mini-gun ammunition cans to fix the problem.⁶⁰

Not all armament modifications resulted from design flaws. Many expedients were a simple attempt to gain more firepower, especially in terms of machine guns. A crewman from B Company, 2nd Battalion, 34th Armor, began modification of his tank by moving the tank commander's .50-caliber machine gun from the M1 cupola to the turret roof. Then he and his crew mates added another M2 .50-caliber machine gun on a tripod mount welded in front of the loader's hatch. A final M2 .50-caliber machine gun found a home on the tank's back deck in yet another mount welded to the exterior of the tank. For a short while the crew even mounted a 7.62-millimeter minigun from an AH-1 Cobra attack helicopter to the mount in front of the loader's station.⁶¹ While most crews did not take the extreme measures described by the crewman from 2nd Battalion, 34th Armor, many did make similar modifications. Tankers from the 1st Marine Division sometimes replaced the 7.62-millimeter coaxial machine gun in their M48A3 tanks with the .50-caliber machine gun from the commander's weapon station. Some Marines went so far as to mount Chinese made RPD light machine guns on their tanks to improve firepower.⁶²

Crews of M113 armored personnel carriers in infantry and cavalry organizations also modified the firepower of their vehicles. The standard kits that provided additional machine guns and gun shields for M113s were widely distributed across Vietnam to increase the lethality and protection of the M113. Since the kits were provided by the Army, they were not really field expedient. Many crews, however, took the kits to the next level by adding more, or different, machine guns. Additionally, crews mounted a

variety of other weapons including grenade launchers, 106-millimeter recoilless rifles and 7.62-millimeter mini-guns.⁶³

The widespread use of field expedient armament to improve overall protection of armored vehicles resulted from the type of threat American crews faced in Vietnam. The traditional antiarmor threat in the form of enemy tanks and antitank guns did not exist in Vietnam until 1972. Crews could focus on fighting the dismounted Vietnamese they faced every day. This focus on enemy infantry led crews to find creative ways to improve the anti-personnel firepower so vital to fighting in the close terrain and dense vegetation. Armored vehicle crews proved successful in the secondary field expedients they devised.

US commanders initially thought armored vehicles had no place in the fighting in Vietnam. Marine and Army crews, when given the chance, proved they could make significant contributions to the American effort in Vietnam. The particular conditions in Vietnam, especially the enemy's reliance on mines and rocket propelled grenades in lieu of traditional antiarmor weapons, drove the development of several highly successful field expedient modifications that improved the protection that armored vehicles afforded their crews. Rocket propelled grenade screens proved their worth for all types of mounted units. They successfully reduced the effectiveness of rocket propelled grenade warheads against tanks and armored personnel carriers. Crews also successfully modified their vehicles' armament to improve their ability to destroy enemy infantry, thereby improving protection and increasing survivability for US armored vehicle crewman.

As was the case with World War II and the Korean War, armored crews were less successful in improving the primary protection of their vehicles against the greatest threat they faced. Even though many units religiously sandbagged their vehicles against mine

strikes the majority of deaths of combat vehicle crews still occurred from mines. Barring complete redesign of armored vehicles to incorporate better belly armor, no field expedient could have improved protection for American crews against mines in Vietnam.

¹David A. Niedringhaus, "US Army Armor In Limited War: Armor Employment Techniques In Korea and Vietnam" (Master's Thesis, The University of Ohio, 1987), 3.

²"New Striking Power for the Mobile Arm: the Patton 48," *Armor* 61, no. 4 (1952): 14.

³Robert S. Cameron, "American Tank Development During the Cold War: Maintaining the Edge or Just Getting By?" *Armor* 108, no. 4 (1998): 32.

⁴R. P. Hunnicutt, *Patton, A History of the American Main Battle Tank*, vol. I (Novato, California: Presidio Press, 1984), 436.

⁵Lewis Sorley, "Adaptation and Impact, Mounted Combat in Vietnam," in George F. Hofmann and Donn A. Starry, eds., *Camp Colt to Desert Storm, The History of US Armored Forces* (Lexington, Kentucky: University Press of Kentucky, 1999), 329.

⁶Hunnicutt, *Patton*, 436.

⁷Oscar C. Decker, "The Patton Tanks, Cold War Learning Series," in George F. Hofmann and Donn A. Starry, Ed., *Camp Colt to Desert Storm*, 311.

⁸"Final Report, M551 Sheridan" (Department of the Army, Army Concept Team in Vietnam, 16 May 1969), II-8, V-1.

⁹Burton S. Boudinot, "A Sheridan Memoir: The Early Days," *Armor* 106, no. 1 (1997): 14.

¹⁰Sorley, "Adaptation and Impact," 333.

¹¹"Final Report, M551 Sheridan," I-2.

¹²*Ibid.*, 332.

¹³*Ibid.*, 330.

¹⁴"Study and Evaluation of Countermine Activities , Volume 5 of 7, Protective Equipment" (Department of the Army, Army Concept Team in Vietnam, 28 September 1968), 7.

¹⁵Stanley C. Crist, "M113 APC: Four Decades of Service and Still Showing Potential," *Infantry* 93, no. 4 (2004): 18.

¹⁶Simon Dunstan, *Vietnam Tracks, Armor in Battle 1945-1975* (Novato, California: Presidio Press, 1982), 108.

¹⁷The US Army continues to operate the M113, now in the M113A3 version, in 2006. While no longer a primary infantry or cavalry fighting vehicle, the M113 serves a broad range of organizations as an ancillary vehicle for combat support and combat service support functions.

¹⁸*Ibid.*, 107.

¹⁹*Ibid.*, 105. The ACAV configuration survived the Vietnam era down to the present day. The gun shields that became ubiquitous in Vietnam protected M113 crews in Operations Just Cause, Desert Shield-Storm, Joint Endeavor-Joint Guard. They still provide protection to M113 crews in Operation Iraqi Freedom.

²⁰Kenneth W. Estes, *Marines Under Armor, The Marine Corps and the Armored Fighting Vehicle, 1916-2000* (Annapolis, Maryland: Naval Institute Press, 2000), 215.

²¹T. S. Riggs Jr., "Tanks for Non-Tank Country," *Armor* 79, no. 1 (1970): 52.

²²Sorley, "Adaptation and Impact," 338.

²³United States Marine Corps, *Fleet Marine Force Reference Publication 12-41, Professional Knowledge Gained From Operational Experience in Vietnam, 1967* (Washington, D.C.: Headquarters, United States Marine Corps, 1989), 349.

²⁴Riggs, "Tanks for Non-Tank Country," 52.

²⁵Donn A. Starry, *Armored Combat in Vietnam* (Indianapolis: The Bobbs-Merrill Company, Inc., 1980), 126.

²⁶William T. Vossler, "Armored Vehicle Defense Against RPGs," *Infantry* 92, no. 2 (2003): 28.

²⁷Frank E. Varljen, "Letter to the Editor," *Armor* 106, no. 3 (1997): 39.

²⁸"Final Report, M551 Sheridan," III-1, III-2.

²⁹Dunstan, *Vietnam Tracks*, 8.

³⁰"Landmine and Countermine Warfare, Vietnam, 1964-1969," Prepared for Department of the Army, Chief of Engineers (Washington, D.C., Engineer Agency for Resources Inventories, 1972), xi.

- ³¹Riggs, "Tanks for Non-Tank Country," 53.
- ³²Ibid.
- ³³James F. Walker, "Vietnam: Tanker's War?" *Armor* 106, no. 3 (1997): 27.
- ³⁴"Final Report, M551 Sheridan," III-1, III-2.
- ³⁵"Landmine and Countermine Warfare, Vietnam, 1964-1969," 1.
- ³⁶Dunstan, *Vietnam Tracks*, 100.
- ³⁷Ibid., 100-101.
- ³⁸"Landmine and Countermine Warfare, Vietnam Lessons Learned, 1965-1968 (U)," Prepared for Department of the Army, Chief of Engineers (Washington, D.C., Engineer Agency for Resources Inventories, 1972), 38.
- ³⁹Arthur L. West and Donn A. Starry, "Improved Organization and Equipment for Vietnam," *Armor* 77, no. 3 (1968): 51.
- ⁴⁰Paul D. Walker, *Jungle Dragoon, The Memoir of an Armored Cav Platoon Leader in Vietnam* (Novato, California: Presidio Press, 1999), 92.
- ⁴¹Landmine and Countermine Warfare, Vietnam, 1964-1969, Appendixes II," Prepared for Department of the Army, Chief of Engineers (Washington, D.C., Engineer Agency for Resources Inventories, 1972), H-47.
- ⁴²Cameron, "American Tank Development During the Cold War," 32.
- ⁴³Dennis C. Fresch, "Da Nang-Hoi An, A Tank Skirmish in Quang Nam Province," in John F. Antal and Bradley T. Gericke, eds., *City Fights, Selected Histories of Urban Combat from World War II to Vietnam* (New York: Presidio Press, 2003), 377. The author was a Marine gunner on a M48A3 Patton tank during the Vietnam War.
- ⁴⁴Dunstan, *Vietnam Tracks*, 69.
- ⁴⁵Estes, *Marines Under Armor*, 167.
- ⁴⁶"Study and Evaluation of Countermine Activities," 15.
- ⁴⁷Ibid., 3
- ⁴⁸Ibid., B-2.
- ⁴⁹Ibid., 17.
- ⁵⁰Starry, *Armored Combat in Vietnam*, 81.

⁵¹Frederick E. Oldinsky, "Armor In Vietnam," (Master's Thesis, Trinity University, 1976), 194.

⁵²"News Notes," *Armor* 77, no. 6 (1968): 55. The concept of side skirts to cover the track and suspensions of armored vehicles manifests itself currently in the armored skirts of the M1 Abrams and M2 Bradley series armored vehicles still in use by the US Army in 2006.

⁵³Fresch, "Da Nang-Hoi An," 377; and Riggs, "Tanks for Non-Tank Country," 53.

⁵⁴Andrew H. Anderson, "Fence In a Poppa Charlie? You Must Be Kidding!," *Armor* 79, no. 6 (1970): 13.

⁵⁵Walker, "Vietnam: Tanker's War?" 26; and John B. Poindexter, "The Anonymous Battle," *Armor* 109, no. 1 (2000): 21; and "Combat Operations After Action Report for Operation Macarthur" (Headquarters, 2nd Squadron, 1st US Cavalry, 9 February 1969), 24.

⁵⁶A testament to the effectiveness of RPG screens is the fact that the US Army has added slat armor to the current Stryker vehicle for employment in Operation Iraqi Freedom. The slat armor currently serves to provide stand off to detonate rocket propelled grenades fired at Strykers before the projectile reaches the actual vehicle body.

⁵⁷Ralph Zumbro, *Tank Sergeant* (Novato, California: Presidio Press, 1986), 67.

⁵⁸Walker, "Vietnam: Tanker's War?," 26.

⁵⁹West and Starry, "Improved Organization and Equipment for Vietnam," 51.

⁶⁰"Final Report, M551 Sheridan," II-12.

⁶¹Dave Decker, "The Grim Reaper," *Armor* 108, no. 3 (1998): 32

⁶²Fresch, "Da Nang-Hoi An," 376.

⁶³Vossler, "Armored Vehicle Defense Against RPGs," 29; and Dunstan, *Vietnam Tracks*, 107.

CHAPTER 5

CONCLUSION

American crewmen searched for methods to improve the survivability of their armored vehicles during World War II, the Korean War and the Vietnam War. In each war, crews responded to the particular environment they experienced. Enemy antiarmor capability drove field expedient modifications. Crews found, during all three wars, effective techniques to counter some of the threats posed by the enemy. During all three wars, however, crews' attempts to counter the enemy's primary armor killing mechanisms failed to produce the desired result. When analyzed in terms of effectiveness against the enemy's primary killing capacity, the field expedients modifications that armored crews created failed to significantly increase the protection of their armored vehicles.

The greatest threat from German forces of World War II to American armored vehicles came from large caliber antitank rifles mounted on tanks, self-propelled guns and towed antitank guns. Man-portable antiarmor weapons like the *panzerfaust* and *panzerschreck* also posed a significant threat to US armored vehicle crews. In the Pacific theater of operations, the primary Japanese threat came from infantry antiarmor weapons such as hand emplaced mines, demolitions charge and hand grenades. The Japanese did use antiarmor guns; but they were much less prevalent and much less effective than German antitank systems.

Against the German primary threat the Americans found themselves at an immediate disadvantage due to the lack of protection that their tanks, tank destroyers and armored cars provided for their crews. Soldiers and marines developed numerous

techniques to attempt to improve the primary protection of their armored vehicles.

Widespread use of sandbags, concrete and additional welded steel all failed to significantly improve the effectiveness of the armor on US vehicles against German tanks and antitank guns. Until the German collapse in spring 1945, US crews continued to suffer high loss rates of armored vehicles to the German's primary antiarmor systems.

The same sandbags, cement and welded on steel did improve the primary protection afforded to US armored vehicles against German shaped charge weapons like the *panzerfaust* and *panzerschreck*. US field expedients reduced the effectiveness of these weapons by creating stand off to detonate the shaped charge prematurely. This premature detonation caused the penetrating molten jet produced by the shaped charge to dissipate prior to coming into contact with the actual armored skin of the vehicle.

The different nature of the Japanese threat in the Pacific worked in the Army and Marine crews' favor in terms of armored vehicle protection. The relative weakness of Japanese antiarmor weapons required less field improvisation on the part of Pacific theater armored crews in terms of primary protection.

In terms of secondary protection, however, crews who fought the Japanese found great success with creating devices and armaments modifications that increased their armored vehicles effectiveness in destroying Japanese infantry before they got close enough to employ their hand-held antiarmor weapons. Field expedient improvements such as tank-infantry communications systems, flame throwers and added weapons proved effective in keeping Japanese forces far away enough from armored vehicles.

Modifications to improve secondary protection of armored vehicles in Europe met with great success. Infantry-tank communication was improved by the field expedient

telephones devised by crews and their infantry counterparts. Armored vehicle crews increased the enemy's difficulty in target acquisition and engagement with a variety of paint and camouflage techniques. One innovation in particular, the hedgerow cutter developed in Normandy, assisted the First US Army significantly in solving the tactical problem that the hedgerows presented. The hedgerow cutter was so successful, in fact, that during the Vietnam War the US Army's Combat Development Command and Army Material Command recommended to units in theater that they copy the hedgerow cutter modifications from 1944 to deal with the problem of movement through the heavy jungle of Vietnam.¹

The Chinese and North Korean threat during the Korean War provided, relative to World War II and Vietnam, little impetus for field expedient modifications. Once the limited supply of North Korean T-34/85 tanks was destroyed the enemy possessed little capability in terms of antiarmor weapons. American crewmen saw little need to improve the protection their mounts offered. Crews used sandbags extensively to improve primary protection against enemy artillery and mortar fire once they found themselves in static defensive positions. Mines did pose a significant threat to American mounted units in Korea. Little evidence exists to show any significant use of sandbags, or any other techniques, to counter the mine threat from the Chinese and North Koreans. The American lack of mine and countermining warfare capability during the Korean War foreshadowed the tremendous difficulty that the US Army and Marine Corps faced in South Vietnam later.

A threat from large caliber antiarmor weapons did not exist during the Vietnam War. The greatest threat to US armored vehicles came from mines and rocket propelled

grenades. American crews responded with vigor to the mine threat, primarily through the use of sandbags, to attempt to improve the primary protection of their vehicles. The crews' efforts resulted in little real improvement to protection. The field modifications of perforated steel planking, sandbagging and rocket propelled grenade screens did offer significant improvement in protection. Soldiers that manned M113 vehicles, in particular, benefited to a great extent from the development of the rocket propelled grenade screen.

Addition and modification of armament comprised a wide spread set of secondary protection modifications in Vietnam. Tank and armored personnel carrier crews executed a number of different field expedients that improved the fire power of their vehicles against infantry attack. Secondary protection efforts by Vietnam War crews increased the protection that their armored vehicles provided.

Taken together, field expedient modifications to armored vehicles during World War II, Korea and Vietnam increased the overall protection provided to the US Army and Marine Corps. Secondary protection modifications and primary modifications against secondary threats were successful in increasing protection. Improvement of the protection against the enemy's primary armor killing mechanisms, however, proved unattainable. From the perspective of a crewman, perceived improvement against any of the multitude of threats they faced, justified the effort and resources expended to create the field expedients. This psychological aspect of the effectiveness of field expedients in all three wars was difficult to measure. Contemporary statements from all three wars emphasized the point that, if a crew *thought* a field expedient would protect them, then it was worth the effort. The logic was that a crew fought with more confidence if they believed their vehicle protected them. Field expedients effectively increased crew confidence and crew

capability, thereby leading to the characterization that those field expedient modifications were effective.

The conclusions that this work derived can be applied to contemporary military operations in two ways. The first implication for contemporary operations in Iraq and Afghanistan is that field expedients do provide improved protection for vehicles and crews within certain limitations. Field improvisations generally do not solve basic imbalances between a vehicle's basic protection and the enemy's primary antiarmor killing systems. Against secondary threats, however, field expedients do provide tangible improvements in protection.

A second implication for contemporary military operations is that the psychological impact of field expedients on vehicle crew members very often justifies the expenditure of resources required to make the modifications. Additionally, commanders and leaders at all levels should be aware of, and tolerant of, field expedient measures that their crews might develop during the course of operations. Leaders should encourage subordinates to explore and experiment with field expedient protection techniques. Three previous wars proved that inventive American crews could devise ways of increasing their vehicles' protection and enhance combat effectiveness.

¹“Annex H, USAMC Comments and Annex I, USCONARC Comments of the Review and Analysis of the Evaluation of US Army Mechanized and Armor Combat Operations in Vietnam(U)” (Headquarters, United States Army Combat Developments Command, Fort Belvoir, Virginia, 15 May 1967), H-8.

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